THE FLORIDA STATE UNIVERSITY

COLLEGE OF ARTS AND SCIENCES

A BIOARCHAEOLOGICAL ASSESSMENT OF HEALTH

FROM FLORIDA'S ARCHAIC:

APPLICATION OF THE WESTERN HEMISPHERE HEALTH INDEX

TO THE REMAINS FROM WINDOVER (8BR246)

By

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ABSTRACT

Windover (8BR46) represents one of the most ancient and well-preserved skeletal collections in North America. Excavated in the 1980s from a mortuary pond near Florida's eastern coast, the remains represent over 168 individuals, from neonates to elderly, enabling an evaluation of health at all stages of life. Through the application of the Western Hemisphere Health Index (Steckel and Rose, 2002), the overall health of the Windover population has been assessed and compared to populations utilizing various subsistence practices, in a variety of geographic regions spanning 7,000 years of human history. This assessment indicates a surprisingly low overall health score for a pre-agricultural population, with relatively elevated rates of trauma, anemia, and hypoplastic defects yet low incidences of dental and degenerative joint disease. Males had better overall health than females, yet stable isotope analyses indicate there were no differences in types of foods consumed.

Several factors were explored in an attempt to explain the low health scores of Windover. The health of hunter-gatherer populations was evaluated, yet all but one of these groups scored high on the index. Methodological issues were examined, which showed that interobserver error was quite high in some categories. However, the majority of the scoring criteria utilize presence/absence values, minimizing interobserver error. The trauma criteria were found to be extremely limiting, since it excludes all torso fractures. This prevents the evaluation of some forms of mechanical loading, interpersonal violence, and multi-trauma. The computation of data was found to be erratic at times, with scores changing in the absence of new data. Overall, the methodology is straightforward, easy to follow and is now available online.

The final section explored factors that would have had negative implications on health at Windover. This included environmental conditions conducive to the presence and spread of insects, parasites and infectious organisms; a riverine-based diet that was nutritionally adequate yet at times in short supply due to environmental fluctuations; and

the social climate of semi-sedentary hunter-gatherers. It is proposed that Windover may represent the incipient stages of sedentism based on the size of the cemetery and archaeobotanical evidence indicating seasonal occupation of the site. The low scores obtained by the Windover population could be a reflection of a population's attempt to transition from a mobile to a more sedentary existence, with the associated health costs inherent to larger, stationary populations.

CHAPTER 1 - INTRODUCTION

The bioarchaeological examination of human skeletal remains permits the analysis of health in historic and prehistoric populations. Through the interpretation of indicators of health among skeletal populations, we can gauge the level of nutrition, adaptation to environment, and disease prevalence among past societies. This research examines the health of an Archaic population living in eastern Central Florida. Dated to over 7,000 BP, the remains from Windover (8BR246) provide a glimpse into the lives and health of early North Americans and act as a baseline for comparisons of health across time.

Through the application of the Western Hemisphere Health Index (WHHI) (Steckel and Rose, 2002), the remains from Windover will be evaluated using a standard protocol for assessing the level of overall health of an Archaic population. It will provide a mechanism for examining the overall health of people in east central Florida in the early mid-Holocene, as well as the ability to compare their level of health to other populations included in the Western Hemisphere Health Index Survey.

There are three primary goals of this research:
1. To assess the individual and overall health of the people from Windover.
2. To compare the scores from Windover to populations utilizing different subsistence regimes in different geographic regions through time.
3. To evaluate the Western Hemisphere Health Index as a means of assessing health of past populations.

The Western Hemisphere Health Index (WHHI) is a strategy that enables bioarchaeologists to overcome several problems inherent to the field. It utilizes a standard protocol to insure that data collection is uniform throughout the survey. Skeletal indicators are scored primarily for presence or absence, which reduces interobserver error. It includes a large number of individuals from broad geographic ranges, allowing comparisons among populations utilizing various subsistence strategies in different ecological zones over time. The sites included in the WHHI date from 5000BC to the late nineteenth century, which provides insight into how health has changed over the course of prehistory and history.

Windover will be a significant addition to the WHHI dataset. It predates all populations within the dataset and provides the only sample site from Florida.

Bioarchaeology

The analysis of human skeletal remains was not always considered an integral part of archaeological studies. Prior to the 1980s, data on human remains consisted primarily of age and sex and was usually relocated to the appendices of reports. Like paleopathology, the early years of skeletal analysis focused on description at the individual level. Buikstra first coined the term "bio-archeology" to describe the integrative, problem-oriented research that combines interdisciplinary cooperation in pre-field planning of archaeological projects, excavations that include persons skilled in osteological recognition and recovery, and intensive integration of skeletal biologists in all stages of research design and execution (Buikstra, 1991). It wasn't until researchers began broad-based comparisons within and between populations that the potential for bioarchaeological analyses was fully appreciated.

Lacking standardized protocols, data collection and analysis varied among researchers, making comparisons across populations problematic. The implementation of the Native American Graves Protection and Repatriation Act (NAGPRA) in 1990 necessitated standardized formats for dealing with skeletal inventories. The publication of *Standards for Data Collection from Human Skeletal Remains* (Buikstra and Ubelaker, 1994) was the first comprehensive manual that provided standardized guidelines for the

analysis of human skeletal remains and the recording of data. Bioarchaeology allows us to address issues of nutrition, disease, physiological stress, activity-related skeletal changes, and quality of life in past populations.

Comparisons of health among populations provide insight into population variability with respect to stress, as well as a population's ability to respond and adapt to such stress. Larson (1997:6) defines "stress" as the physiological disruption resulting from impoverished environmental circumstances and considers it a product of three key factors, including (1) environmental constraints; (2) cultural systems and (3) host resistance. The analysis of stressors in prehistoric populations reveals a complex interaction in which there is differential physiological disruption, thus requiring an understanding of the hierarchical response unraveling the success and difficulties that a cultural system, a population, and an individual may have in adjusting to their environment (Goodman et al., 1988:169).

Bioarchaeology utilizes human osteology in an attempt to understand biological parameters of past human populations (White, 2000). Bioarchaeology can also be utilized to infer social parameters since the lifestyle of an individual leaves clues on the skeleton. There has been a clear association between lifestyle and health of given populations, over time (Powell et al., 1991; Larsen, 1997; Steinbock, 1976; Webb, 1995; Lambert, 1993; Bridges, 1994; Bridges, 1991), with considerable debate as to which subsistence strategies are more conducive to healthy individuals.

The advent of agriculture and associated changes in social structure changed the lives of mobile and semi-sedentary hunter/gatherers by providing more reliable food sources and enabling population expansion through the establishment of permanent occupation sites (Bogucki, 1999). Sedentary settlements allowed storage of food provisions, which minimized periods of scarcity experienced by those dependent on hunting and foraging. Instead of searching for food, agriculturalists could base their settlements within areas conducive to the growing of necessary food sources. However, the advent of population-based bioarchaeological studies would soon call into question many of the "beneficial" attributes once associated with the adoption of agriculture. Taken as a whole, the popular and scholarly perception that quality of life improved with the acquisition of agriculture in incorrect (Larsen, 1995).

The transition from smaller mobile hunting and gathering groups to larger sedentary agricultural populations was accompanied by costs in terms of the overall health of the individual. These costs were comprehensively evaluated in 1982 at a conference that brought together physical anthropologists interested in examining the biocultural effects of the adoption of agriculture. The papers presented within the conference examined the health of individuals before, during and after the transition to agriculture by examining signs of nutritional stress and pathology among archaeological skeletal remains. These papers, later published in *Paleopathology at the Origins of Agriculture* (Cohen and Armelagos, 1984), showed that the advent of agriculture was in fact frequently accompanied by general decreases in health.

Diminished variability in diet resulted in greater reliance on lower-quality food sources. The diet of hunters and gatherers, which consisted of animal protein and local plants, was replaced by foods such as maize, which provided less protein and inhibited the metabolism of protein within the body. The process of intensification had produced diets increasingly focused on a few highly productive plant food sources that were relatively starchy and low in protein, minerals, and vitamins (Roosevelt, 1984). One major result of a high-starch, low protein diet is an imbalanced immunochemical system leding to impaired disease resistance through depletion of antibodies (more commonly in children than adults) and interference with macrophage metabolism (Jerome et al., 1980:99).

Increases in infectious disease were associated with greater population density and attendant problems in sanitation. Sedentism is particularly likely to increase disease transmission of any parasite that must complete essential phases of its life cycle in the soil (or elsewhere outside the human host) before its offspring can reinfect a new individual (Cohen, 1989:41). Sedentism facilitated the establishment of trade networks, which increased the spread of infectious agents between populations. Intimate interpersonal interaction during trading-center fairs favored direct aerosol transmission of viruses, making native trading centers the foci of communicable diseases (Dobyns, 1992).

Increases in population density may also have led to increases in interpersonal conflict, resulting in greater incidence of skeletal fractures. Warfare is seen as an adaptive response to ecological conditions such as population pressure and limited resources,

functioning to increase access to resources (Robarchek, 1994:308). The advent of agriculture caused changes in longbone dimensions. Larsen and Ruff (1991) note diachronic trends in adult body size reduction for the north Georgia coast following the advent of agriculture, which they attribute to reduced activity among agriculturalists compounded by poor nutrition. The effects of agriculture on physical health are apparent when we examine the skeletal remains of past populations.

Bridges (1991) compared the rates of degenerative joint disease among hunter-gatherers with those of agriculturalists in Northwestern Alabama and found a higher prevalence of arthritis in Archaic populations. However, she also found that agriculturalists had increased levels of bone strength, as measured through long bone dimensions, bending and torsion strength, and bilateral asymmetry than individuals from the Archaic period, suggesting increases in workload with the adaptation to agriculture.

Molleson (1994) examined the skeletal changes that accompanied a shift from hunting and gathering to agriculture among the people of Abu Hureya in the Near East. These changes, which consisted of degenerative changes to the vertebrae, knees, and feet were caused by the physical demands of carrying heavy loads, pounding grain, and prolonged squatting. Among the people of the Channel Islands, Lambert (1993) examined skeletal changes that occurred as a result of a shift from a generalized hunting and gathering strategy to one that focused primarily on fishing. Despite the increase in protein that accompanied this shift, there was a general deterioration in health among these people, resulting in changes in stature and an increase in inflammatory bone lesions.

Papathanasiou (2005) studied health changes following the adoption of agriculture in Greece. The most frequent pathological conditions observed among the population of over 161 individuals included high incidences of cribra orbitalia and porotic hyperostosis resulting from a diet based on domesticated cereals; osteoarthritis indicative of intensive physical activity and heavy workloads; and elevated incidences of healed depressed cranial fractures from violent, nonlethal confrontations.

Oxenham, et al. (2005) examined increasing rates of infectious disease that accompanied the transition from sedentary coastal foragers to centralized chiefdoms with attendant development and intensification of agriculture. The skeletal evidence for

infectious disease was absent among the earlier foraging group while over 10% of the latter group exhibited lesions consistent with either infectious disease or immune system disorders.

Schurr and Powell (2005) examined changes in stable nitrogen- and carbon-isotopes among pre-agricultural and highly agricultural groups from eastern North America in order to determine whether reduction in weaning-time contributed to population growths that accompanied the advent of agriculture. Their research indicates that weaning-times remained consistent throughout these changes in subsistence and therefore did not contribute to higher birth rates in the areas studied.

Studies of skeletal material from the Channel Islands have found high frequencies of depressed cranial fractures over a 7,000-year temporal span of prehistory (Lambert, 1994). Walker (1989) found that the incidence of cranial injuries increased significantly between the early and late prehistoric periods of the Channel Islands and attributed this increase to social and ecological conscription in the area due to increased competition for resources.

Although bioarchaeological studies have become more refined and widespread, they continue to suffer from several issues, namely inconsistencies in data collection, scoring criteria, and pathology description and diagnosis. The Western Hemisphere Health Index was developed so that these inconsistencies are minimized. The index utilizes a standard protocol for data collection that is clear and concise. The scores are generally based on presence or absence of pathological conditions, thereby reducing inter-observer error, allowing comparison across populations.

Windover represents a semi-sedentary group of hunter/gatherers. Although still in dispute, it is generally believed the cultivation of plants among northern Floridians took place around AD 750 (Milanich, 1994). Therefore, Windover predates the adoption of agriculture by over six thousand years. Based on the compilation of work presented in *Paleopathology at the Origins of Agriculture* (Cohen and Armelagos, 1984), the Windover population would be expected to exhibit better overall health than populations living in denser agricultural settings. Analyses of botanical remains from gut areas of several burials (Newsom, 2002) indicate it was utilized during the late summer/early fall months. Thus, the people from Windover were probably moving between sites, based on

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seasonality. Movement between seasonal sites would have restricted the size of the group so overcrowding would likely not have been an issue, minimizing the spread of infectious disease. Stable isotope analyses indicate a riverine diet, possibly turtle, catfish and duck (Tuross et al., 1994). Combining these foods with locally gathered plants would have provided a varied diet with adequate protein, reducing the occurrence of iron deficiency anemia. Paleoethnobotanical reconstruction indicates an array of fresh fruits, nuts, greens, seeds, and tubers from wetland species that helped to further diversify diet at Windover (Newsom, 2002). The Windover diet will be discussed in greater detail in Chapter 4.

This research is based on the assumption that the Windover population will have a high overall quality of life score, low incidences of infectious disease and nutritional stress and rank near the top of the Western Hemisphere Health dataset.

CHAPTER 2 - MATERIALS AND METHODS

Windover

Skeletal samples older than 5000 years, in North America and elsewhere, are exceptionally rare. As part of the ongoing research on the Windover population, Dr. Glen Doran, Department of Anthropology at Florida State University and students have been compiling a North American skeletal database that provides temporal, geographic, and sample size information for archaeological sites producing human skeletal remains (Figure 2.1). The state of Florida has produced some of the oldest skeletal samples in North America. The Windover population constitutes almost half of all individuals in North America from contexts predating 7,000 years BP, and Florida produces 60 percent (N=194) of this pre-7000-year old sample (Windover, Cutler Ridge, and Warm Mineral Springs) for all of North America (Doran, 2002). With a minimum number of individuals of 168, a broad population profile, a diverse artifact inventory, and exceptional preservation, Windover affords a rare glimpse into the life of Archaic people in Florida.

North Sample Distribution
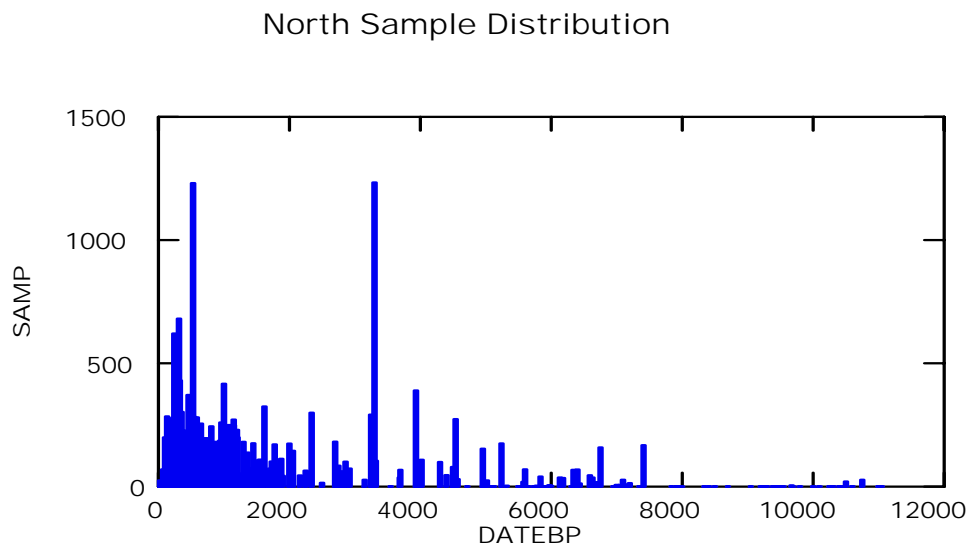
Figure 2.1 Dates of skeletal samples from North America.

The Windover site, a charnel pond located in the east-central Florida coastal area near present-day Titusville, was first discovered in 1982 during construction within the Windover Farms suburban housing development. The subtropical climate was perhaps weaker during the Hypsithermal, corresponding with early use of the pond for interments. Pollen studies from this period indicate dry oak woodland over much of the Florida peninsula with combinations of temperate and tropical vegetation in the area of Windover (Tuross et al., 1994). By 7000 years BP, the climate had stabilized, resembling present conditions.

Charnel, or mortuary ponds consist of shallow ponds underlain by intact peat sediments into which burials were placed during the Early and Middle Archaic times (Doran, 2002.). Similar sites have been discovered throughout Florida, including Bay West (Beriault et al., 1981), located in the Southwest; Republic Groves (Saunders, 1972), located in the south-central region of the state; and Little Salt Springs (Clausen et al., 1979), located near the west coast of Florida (Figure 2.2). Based on radiocarbon dates obtained from the central portion of the pond, the oldest peat began accumulating approximately 10,750 years BP (Doran and Dickel, 1988b). The mean of nine radiocarbon dates on human bone, wooden stakes, and remains of a bottle gourd is 7,442 radiocarbon years BP, making Windover the largest sample of its antiquity in North America (Doran and Dickel, 1988a).
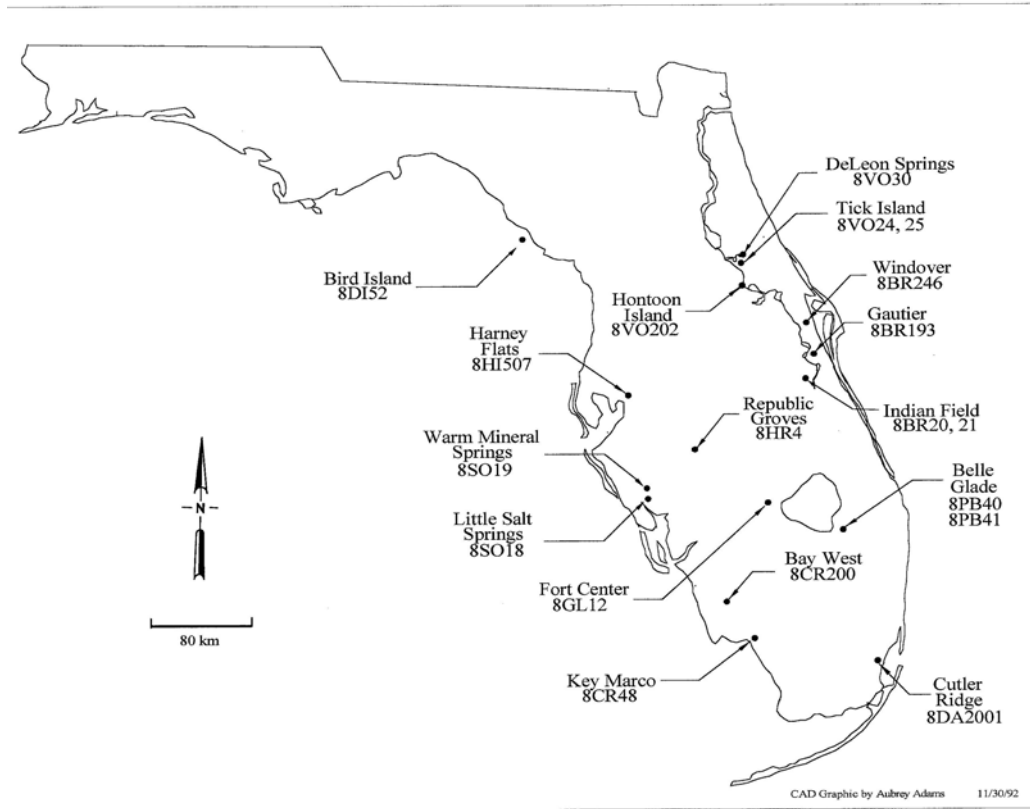
Figure 2.2 Map of early Florida sites producing human skeletal remains (Doran, 2002:3).

Table 2.1 provides the dates, number of individuals, and references for Florida sites that have produced human skeletal remains.

Table 2.1 Pertinent Florida archaeological sites producing human remains (Doran, 2002).

SITE NAME/NUMBER	RADIOCARBON YEARS BP	NUMBER OF INDIVIDUALS	REFERENCE
Bird Island 8DI52	4,570	40	Stojanowski and Doran, 1998
Cutler Ridge 8DA2001	9,670 +/- 130	5	Carr, 1986
Fort Center 8GL12	1,450	300	Miller-Shaivitz, 1986
Gautier 8BR193	3,320 (Middle Archaic) 1,600 (Late)	105 26	Maples, 1987
Little Salt Spring 8SO18	6,180 +/- 95	35	Clausen et al., 1979
Republic Groves 8HR4	6,520 – 5,745	37	Saunders, 1972
Tick Island 8VO24, 25	5,450 – 5,030	175	Jahn and Bullen, 1978
Warm Mineral Spr. 8SO19	10,500 +/- 1,700	21	Clausen et al., 1979 Lien, 1983
Windover 8BR246	8,120 – 6,990	168	Doran and Dickel, 1988b

The excavation of Windover spanned three field seasons (1984-1986). Approximately half of the pond was excavated, a significant challenge due to extensive dewatering strategies over such a large area. It enabled the exposure, preservation, and excavation of skeletal material, as well as fragile textiles and associated grave goods. An unusually neutral pH, high sulphur levels, highly mineralized water, and an anaerobic

peat environment, produced a physical environment that afforded exceptional preservation of organic remains (Stojanowski et al., 2002).

One of the most fascinating aspects of preservation from Windover was the recovery of human brain tissue from ninety-one crania. Fragments from one cranium were dated to 6,990 +/- 70 yr BP using an accelerator-mass spectrometry method on isolated collagen (Doran et al., 1986). Gross examination of the brain-like masses following removal from the skull disclosed the external gyral pattern of an atrophic human brain shrunk to about one-quarter its original size and, although altered in consistency, still exhibited gross anatomical features of contemporary brains (Doran et al., 1986).

The remains of over 168 individuals were excavated. The population consists of an approximately equal ratio of males to females, a diverse population profile with ages ranging from infant to 65+ years, and the exceptionally preserved remains of a large number of sub-adults (Figure 2.3) comprising approximately half (52 percent) of the sample (Stojanowski et al., 2002). The state of preservation at Windover has permitted cellular and molecular analyses, including the first sequence of a nuclear gene from ancient human remains (Tuross et al., 1994). Windover provides a rare glimpse into the lifestyle of the people of Florida's Archaic and facilitates a bioarchaeological approach to population studies.

Figure 2.3 Reconstructed child's skull (Windover archival photos).

The Windover site has been the subject of numerous scientific inquiries. These include the logistics of wet site archaeology, preservation of organic remains, mortuary analysis, and bioarchaeological studies. Doran and Dickel (1988) examined the multidisciplinary approach utilized during the excavations at Windover. The complexity of the site necessitated a detailed research strategy. Logistics included dewatering strategies to enable excavation, which included the placement of drainage wells throughout the site. The preservation of waterlogged skeletal and organic remains required immediate action to prevent their drying out when removed from the ground.

Doran and Dickel (1988b) reported on the radiometric dating employed on material from Windover, which included human bone, peat from various levels within the pond, wooden stakes believed to have been utilized to mark burial locations or keep the bodies submerged below the waterline, and a bottle gourd (Doran et al., 1990) recovered from one of the burials. Stone et al. (1990) evaluated the preservation measures applied to waterlogged bone excavated from the site, comparing two types of consolidants used on the skeletal remains.

The mortuary practices employed at Windover have also been examined. Hamlin (2001) evaluated the division of labor among people of Windover by examining the

functionality of associated grave goods in relation to gender. Dickel (2002) analyzed grave good distributions among the burials, which exhibited no significant association to the age or sex of the individual. One of the grave goods, the bottle gourd *Lagenaria siceraria* was dated to over 7,200 radiocarbon years B.P. and provides the earliest documentation of bottle gourds north of Mexico (Doran et al., 1990).

Several bioarchaeological studies have been published on the Windover population. In 1986 Doran et al. reported on the recovery and analysis of brain tissue discovered in over 90 of the crania buried within the pond (Figure 2.4). The brain tissue, dated to over 7,790 BP still retained their gross anatomical features and at the time was the oldest known example of preserved human cell structure and DNA (Doran et al., 1986). Tuross et al. (1994) examined subsistence by utilizing stable-isotope and archaeobotanical analysis. These studies indicated that the pond was utilized during the midsummer/fall period and that the people from Windover were practicing a riverine-dominated subsistence that may have included turtle, duck, and catfish.

Figure 2.4 Preserved brain tissue (Windover archival photos).

A variety of pathologies have been documented among the Windover population. The analysis of skeletal fractures (Smith, 2003) indicates a lack of evidence of

interpersonal violence and similar fracture frequencies between the sexes. The evaluation of nutritional stress markers (Estes, 1988) indicates that frequencies of porotic hyperostosis were high compared to those observed in other large skeletal populations (Indian Knoll and Dickson Mound). A subadult of approximately 15 years of age, examined by Dickel and Doran (1989), was found to have multiple pathologies that included spina bifida aperta, severe infection of the right tibia and fibula, and disuse atrophy of the long bones (Figure 2.5). Windover continues to provide insight into Florida's Archaic and research continues.

Figure 2.5 Spina bifida in subadult remains (Photo courtesy G. Sutton).

All Archaic cultures are characterized by what could be called "broad-spectrum" foraging adaptations, which vary with the biotic richness of various habitats (Bogucki, 1999). The people of Windover followed the hunting, fishing, and gathering lifestyle

typical of Archaic peoples.   Their social organization probably consisted of small foraging bands that practiced seasonal migration, as evidenced in the archaeobotanical analysis of plant remains found within the burials. This movement could invariably led to encounters with other groups in the area. Travel, subsistence practices, and overall health certainly left its evidence on their skeletal remains. By evaluating their levels of health, as seen through their skeletal remains, and comparing these levels to other populations across time and space, we will add to the growing body of knowledge concerning the physical health of past populations.

Windover Skeletal Population

The population profile afforded by the remains from Windover allows an assessment of health from all age groups. Adequacy of diet, activity related skeletal manifestations, and overall health can be analyzed from all periods of growth, development, and maturity. The working number of individuals within the Windover population is 168. For the purpose of this research, however, the population was reduced to 133 due to the commingling of some burials, which prevented calculation of an individual WHHI score. Although bone preservation is exceptional for its antiquity, many individuals within the population are incomplete.

The age distribution within the population is provided below. Age was assigned at the time of excavation based on dental eruption, epiphyseal closure and dental seriation. Sex was based on cranial and postcranial morphology, as well as physical traits (Phenice, 1969) and scores (Nemeskeri, 1970) of the pelvis (Dickel and Doran, 1989). Age has been adjusted per WHHI protocol.
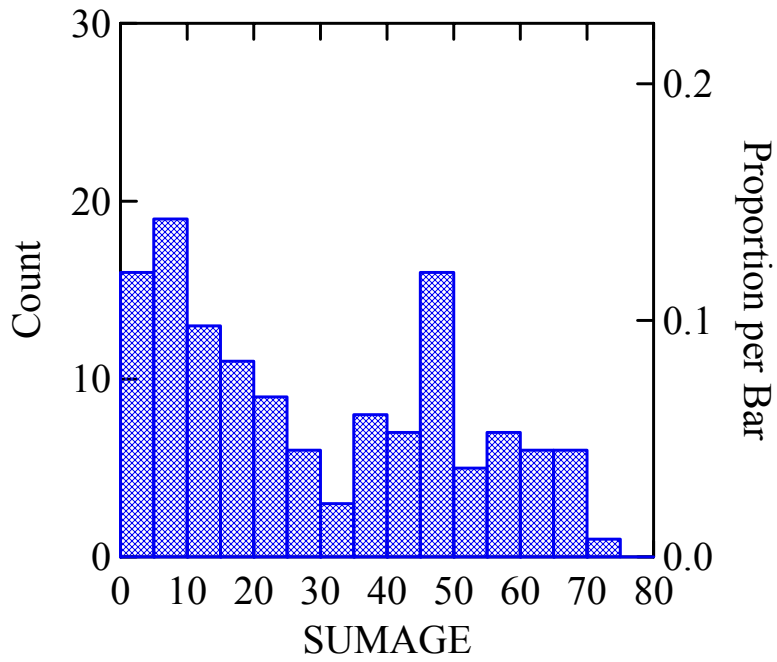
Figure 2.6 Age distribution of the Windover study population.
The distribution of sex is provided in Figure 2.7.

1 = Female

3 = Male

5 = Indeterminate
due to Subadult

6 = Unknown
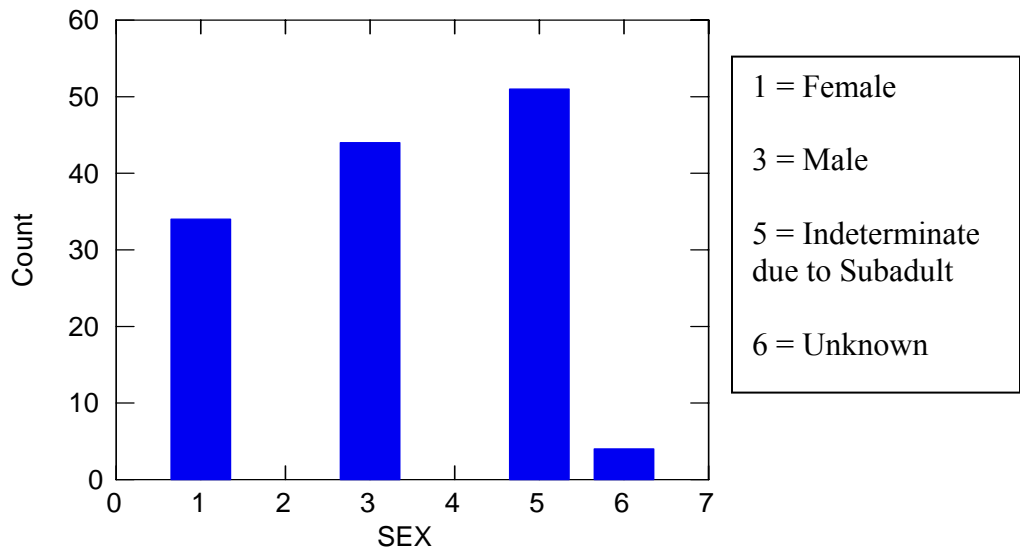
Figure 2.7 Sex distribution of the Windover population.

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The Western Hemisphere Health Index

Adaptation is a fundamental concern and focus of investigation in biological anthropology (Hutchinson, 2002:10). The success of environmental adaptation can be evidenced in human skeletal remains. The Western Hemisphere Health Index (Steckel and Rose, 2002) was developed to evaluate health over broad geographic areas and temporal periods.

Organized in the late 1980's by Richard Steckel, professor of Economics and Anthropology at Ohio State University and Jerome Rose, professor of Anthropology at the University of Arkansas, the project brought together physical anthropologists, demographers, and economic and medical historians for a multidisciplinary approach to evaluating the history of health in the Western Hemisphere using data from human skeletal remains from archaeological contexts.

The data include 12,520 skeletons from 218 archaeological sites located in North, Central, and South America. The sites were integrated based on chronological and ecological similarity, for a total of 65 sites. Eighty percent of the individuals are Native American, with Euro-Americans and African-Americans accounting for equal percentages of the remaining 20%. The temporal distribution includes individuals dating from 7000 years before present to the early twentieth century (Figure 2.8). Of the Native Americans, 11.9% are from Central America, 22% are from South America, and the remainder from North America. The populations are coded for site name, site number, date, and group (N=Native American; E=Euro-American; A=African-American). A map of the sites is provided in Figure 2.9.
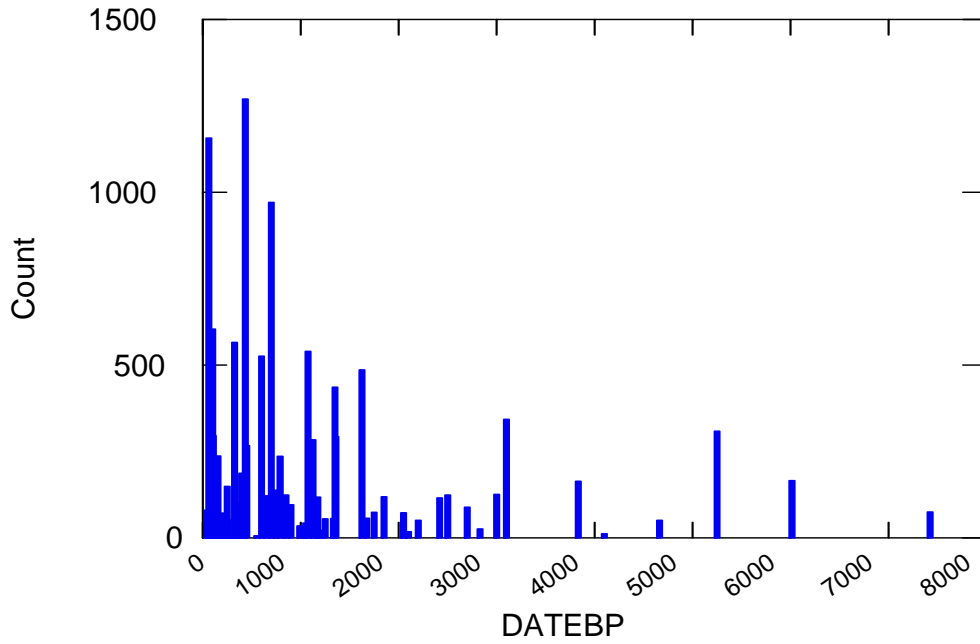
Figure 2.8 The temporal distribution of sites within the Western Hemisphere Health database.

Figure 2.9 Map of sites included in the Western Hemisphere Health Index (Steckel and Rose, 2002:inset).

The health index utilizes two components: length and quality of life. Because of the problems inherent in estimating life expectancy from skeletal populations, quality of life is emphasized and gauged based on the assessment of seven skeletal indicators of health, described below.

Infection/Periosteal Reactions

Periostitis is a surface inflammation of bone (Figure 2.10), manifested by fine pitting, longitudinal striation, and plaque-like new bone formation on the original cortical surface (Roberts and Manchester 1997:129). It is most often attributed to infectious disease but can also occur secondary to traumatic injury. Osteomyelitis is an infection of bone involving the marrow (Ortner and Putschar, 1981:41). It results from introduction of pyogenic, or pus-producing, bacteria into bone, secondary to localized infection or trauma, or from systemic dissemination of bacteria in the bloodstream. It produces pitting and irregularity, as well as periosteal expansion, producing an enlarged, irregular appearance to the bone. Osteomyelitis is typically accompanied by clocae, which are openings that led from the medullary cavity out through the cortical surface of bone that allow the evacuation of pus. The most common causes of osteomyelitis are *Staphylococcus* and *Streptococcus* microorganisms.

Figure 2.10 Periosteal reaction in subadult (#77) (Photo courtesy G. Sutton).

Evidence of bone infection may indicate stress within a population in the form of malnutrition, decreased host resistance, and elevated rates of morbidity and mortality.

Bone inflammation also can be secondary to various forms of systemic infectious disease, such as tuberculosis and syphilis.

According to the WHHI, lesions are considered infectious unless otherwise indicated. Only major lesions of the major long bones are employed. Active and healed lesions are not differentiated. Since the tibia is the most common site for infectious lesions, they are given separate scores from the rest of the postcranial skeleton. The scores are scored as follows:

Tibial Scores

0) No tibia present
1) No infectious lesions of tibia with at least one tibia present for scoring
2) Slight, small discrete patch(es) of periosteal reaction involving less than one-quarter of the tibial surface on one or both tibiae
3) Moderate periosteal reaction involving less than one-half of the tibial surface on one or both tibiae
4) Severe periosteal reaction involving more than one-half of the tibial surface (osteomyelitis is scored here)

Remaining Skeleton

0) No periosteal reaction on any other bone than the tibiae
1) Periosteal reaction on any other bone(s) than the tibiae not caused by trauma
2) Evidence of systemic infection involving any of the bones (including the tibiae) to include specific diseases, such as tuberculosis and syphilis.

Cribra Orbitalia

Cribra orbitalia is defined as lesions in the form of bilateral pitting of the orbital part of the frontal bone (White, 2000:524). It has been associated with iron deficiency anemia, infectious disease, and nutrient losses due to diarrheal diseases. In an examination of over 400 crania from European, tropical, and sub-tropical individuals, it was concluded that iron deficiency anemia, resulting primarily from parasitism, was strongly associated with the occurrence of cribra orbitalia (Mittler and Van Gerven, 1994:293). Cribra orbitalia has also been linked to nutritional deficiencies associated with scurvy (Ortner et al. 1999:322). Cribra orbitalia is often associated with diploe expansion of the cranial bones, known as porotic hyperostosis. Both skeletal manifestations are the

result of the body's attempt to increase production of red blood cells to compensate for the deficiency in iron. Thus, the skeletal lesions are displayed in areas of the flat bones of the cranium where iron production takes place. These typically include the eye orbits (Figure 2.11) and the cranial vault.

Figure 2.11 Cribra orbitalia in subadult remains (Photo courtesy G. Sutton).

According to the WHHI, anemia is indicated by cribra orbitalia and porotic hyperostosis. They are each scored separately. At least one parietal and one orbit must be observable. Scattered fine pitting of parietals and occipitals (porotic pitting) is not scored as positive. There are two fields, each with one numeric character.

<u>Cribra Orbitalia</u>
0) No orbits observed
1) Absent on at least one observable orbit
2) Presence of a lesion
3) Gross lesions with excessive expansion and large area of exposed diploe (form associate with sickle cell anemia and other forms of severe anemia)

<u>Porotic Hyperostosis</u>
0) No parietals to be observed
1) Absent on at least one observable parietal
2) Presence of a lesion
3) Gross lesions with excessive cranial expansion and huge areas of exposed dipoe (form associated with sickle cell and other forms of anemia)

Trauma

Trauma can be defined as a physical injury or wound caused by external force or violence (Bledsoe et al., 1997). The various types of trauma that affect the skeleton include: 1) fracture, 2) dislocation, 3) post-traumatic deformity, and 4) miscellaneous traumatic conditions, including those which do not affect the skeleton directly but can be inferred (Ortner and Putschar 1981).

A fracture is a discontinuity of or crack in skeletal tissue, with or without injury to overlying soft tissues (Aufderheide and Rodriguez-Martin, 1998) and is a common occurrence in the archaeological record (Figure 2.12). There are generally six types of fractures distinguished in the literature. These include transverse, spiral, comminuted, oblique, greenstick, and impacted and are distinguished by the forces that produce them and the resultant injuries. However, the type of fracture may be difficult to identify in the case of well-healed injuries. Fractures may be simple or compound, depending on whether there is an associated break in the skin surface. The examination of traumatic injuries among individuals and fracture patterns within populations provides us with a great deal of information about their daily activities (Nakai et al., 1999:77).

Figure 2.12 Misaligned femur fracture with significant remodeling (Photo courtesy G. Sutton).

Trauma is scored only when there is evidence of healing. It focuses on major bones of the limbs and skull – humerus, radius, ulna, femur, tibia, fibula, and skull – with seven fields, each with one numeric character.

Arm (humerus, radia and ulna)
0) No long bones observable (must have humerus and at least one bone of the forearm to be scored)
1) Not fractured
2) Healed fracture with acceptable alignment
3) Healed and poorly aligned
4) Healed with fusion of the joint
5) Healed fracture with alignment unknown

Leg (femur, tibia and fibula)
0) No long bones observable (must have femur and tibia or fibula)
1) No fracture or trauma
2) Healed fracture with acceptable alignment
3) Healed and poorly aligned with some loss of locomotion
4) Healed with extreme loss of locomotion, such as loss of limb or complete fusion of joint in lower limb
5) Healed with alignment unknown

Nasal and Nasal Process
0) No bones to be observed
1) No fracture
2) Healed fracture

Face Other than Nasal
0) No bones to be observed
1) No fracture
2) Healed fracture

Skull Vault
0) No bones to be observed
1) No fracture
2) Healed fracture

Hand
0) No bones to be observed or not recorded
1) No fracture
2) Healed fracture(s)

Weapon Wounds (to any part of the body and head)
1) No weapon wounds
2) Weapon wound(s)

Linear Enamel Hypoplasia

Linear enamel hypoplasia (LEH) is a condition characterized by transverse lines, pits, and grooves found on the surfaces of tooth crowns indicative of general stress to the individual (White, 2000:115). These defects are due to systemic, local, or hereditary disruption of ameloblast metabolism (Duray, 1990:27). Often termed "indicators of stress" they consist of deficiencies in the enamel matrix composition and are well represented in the archaeological record (Figure 2.13). Enamel hypoplasia is judged to be a non-specific, although sensitive, indicator of stress because it can be brought about by many factors, including nutritional deficiencies, infectious diseases, and metabolic disruptions (Moggi-Cecchi et al., 1994:299). Many recent studies have attempted to use hypoplasias as indicators of the level of generalized metabolic stress present in a given population and at various stages within juvenile development. Moggi-Cecchi et al. (1994), surveying the onset of enamel hypoplasias among 19th Century Italians in Florence, found that children between the ages of 1.5 and 3.5 had the highest onset of defects, which they suggest was directly related to metabolic stress following weaning.

Figure 2.13 Linear enamel hypoplasias (Photo courtesy G. Sutton).

Enamel hypoplasias are reported on maxillary incisors and either the mandibular or maxillary canines for both deciduous and permanent teeth. For the purpose of this research, hypoplasias include only linear grooves that can be clearly seen with the unaided eye under good illumination.

Teeth to be scored:
1) Deciduous maxillary central incisor
2) Deciduous canine (maxillary or mandibular)
3) Permanent maxillary central incisor
4) Permanent canine (maxillary or mandibular)

Teeth scored as follows:
0) Not observable (no suitable teeth, incomplete development, too worn…)
1) No hypoplasias
2) One hypoplasia
3) Two or more hypoplasias

Degenerative Joint Disease

Degenerative joint disease is a condition that commonly results from mechanical wear and tear on the joints of the skeleton due to physical activity (Hough and Sokoloff, 1993). It produces bony deposits around the periphery of joint surfaces in the form of osteophytes (Figure 2.14), and may lead to complete loss of mobility of the joint in severe cases where bony fusion of the joint takes place. The rate and severity of skeletal lesions associated with degenerative joint disease have been tracked through time in an attempt to compare mechanical stress loads on the skeleton in relation to varying subsistence practices (Larsen and Ruff, 1991; Bridges, 1991; Cohen, 1989; Larsen et al., 1992). Typically, the more physically demanding the lifestyle, the greater the incidence and level of severity of degenerative bony changes. However, average life span can affect rates of degenerative joint disease within skeletal populations since the older the individual, the greater likelihood that he or she will display these bony changes over time.

Figure 2.14 Degenerative joint disease in vertebrae (Windover archival photo).

There are eight fields (each with one numeric character) and the most severely affected joint is recorded.

Shoulder and Elbow
0) Joints not available for observation
1) Joints show no sign of degenerative disease
2) Initial osteophyte or deterioration of the joint surfaces
3) Major osteophyte formation and/or destruction of the joint surface, such as eburnation
4) Immobilization of the joint due only to degenerative disease
5) Systemic degenerative disease (e.g. rheumatoid arthritis)

Hip and Knee (scored as one unit)
0) Joints not available for observation
1) Joints show no sign of degenerative disease
2) Initial osteophyte or deterioration of the joint surfaces
3) Major osteophyte formation and/or destruction of the joint surface, such as eburnation
4) Immobilization of the joint
5) Systemic degenerative disease

Vertebrae (scored by type: cervical, thoracic, and lumbar; must have four or more thoracic and two or more cervical or lumbar present; only bodies scored for most severe expression)

Cervical
0) Not observable
1) No lesions on at least two observable vertebrae
2) Initial osteophyte formation along rim of vertebral body(ies)
3) Extensive osteophyte formation along rim of vertebrae
4) Two or more vertebrae fused together

Thoracic
0) Not observable
1) No lesions on at least four observable vertebrae
2) Initial osteophyte formation along rim of vertebral body
3) Extensive osteophyte formation along rim of vertebrae
4) Two or more vertebrae fused together (kyphosis from TB scored under infectious disease)

Lumbar
0) Not observable
1) No lesions on at least two observable vertebrae
2) Initial osteophyte formation along rim of vertebral body(ies)
3) Extensive osteophyte formation along rim of vertebrae
4) Two or more vertebrae fused together

Temporomandibular Joint (only extensive deterioration is recorded, ex. osteophytes, eburnation, and joint surface deterioration)
0) TMJ not observable
1) No deterioration
2) Joint deterioration

Wrist (radio-ulnar joint)
0) Bones not observable or not recorded
1) No degenerative joint disease
2) Degenerative disease of the joint

Bones of the Hand
0) Bones not observable or not recorded
1) No degenerative disease of the joint
2) Degenerative disease of the joint

Stature and Robusticity

The height attained by an individual during their growing years, as well as the changes in dimensions that occur over time due to mechanical loading can indicate the level of nutrition and biological stress experienced by a individual during childhood. It

can also indicate the physical demands placed on the individual throughout life. Poor diet, nutritional deficiency, and disease load can affect final adult height of an individual. In modern populations, child growth and nutritional status has been directly linked to the socioeconomic status of the child's family (Crooks, 1999).

Because mechanical influences on bone are often both localized and directly functionally interpretable, mechanically based analyses can be especially valuable in reconstructing past behavioral patterns from skeletal material (Katzenberg and Saunders, 2000:71). The skeleton reacts to outside stimuli and responds by depositing or resorbing bone where needed. This remodeling alters the shape of bones over time, changing their dimensions. These changes, such as increases in cortical bone strength and cross sectional changes in bone shafts can infer the level of activity and physical demands placed on the bones during life.

Stature and robusticity are recorded according to the following criteria:

Maximum Diaphyseal Length

For juveniles, maximum diaphyseal lengths of left femur; right is recorded if left is not available; no epiphyses recorded (field contains three numeric characters in millimeters)

Femur Length

For adults, maximum length of left femur; may use regression formulas from other bones (field contains three numeric characters in millimeters)

Adult Height

For Native Americans, use Scuilli et al. (1990:275-280); (field contains four character numeric fields in millimeters)

Robusticity

AP = anteroposterior diameter

ML = mediolateral diameter

TA = total subperiosteal area of the adult femor

Measurements are taken from the left femur when available, at midshaft (field contains two numeric characters in millimeters)

$$TA = pi\ (Tap/2)(Tml/2)$$

Tap = anteroposterior diameter at midshaft

Tml = mediolateral diameter at midshaft

TA standardized = [pi (Tap/2)(Tml/2)] max. length cubed

Dental Health

Teeth are often the only part of the body that survives to be excavated, thus can provide valuable information concerning diet, oral hygiene, stress, occupation, cultural behavior and subsistence economy (Roberts and Manchester, 1995). Carious lesions caused by focal destruction of dental hard tissues secondary to bacterial fermentation of dietary carbohydrates have been assessed through time and have been noted to have substantially increased with the shift to agriculture (Hutchinson, 2002; Molnar and Molnar, 1985; Larsen, 1995). Many populations with elevated prevalence of dental caries also exhibit high frequencies of tooth loss and these rates have been assessed in relation to subsistence practices. In foragers, tooth loss is due to pulp exposure from severe occlusal wear, and in farmers, tooth loss is due to periodontal disease and dental caries (Larsen, 1997:80).

Dental abscesses can develop following infiltration of the pulp cavity by bacteria. This can occur secondary to attrition, trauma, or periodontal disease. The accumulation of bacteria within the pulp cavity causes inflammation and the production of pus. As pressure builds from the accumulating pus, a sinus is formed within the wall of the maxilla or mandible, allowing the eventual release of the pus into the surrounding tissues (Figure 2.15).

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Figure2.15 Periapical abscess in right mandible (#53) (Photo courtesy G. Sutton).

Dental disease is recorded for permanent dentition only. Data reported are used to calculate individual (percent of carious teeth per mouth) and population (percent of total carious teeth per group) statistics on caries prevalence (three fields, each with two numeric characters).

1) Total number of permanent teeth observed
2) Total number of permanent teeth lost before death (antemortem)
3) Total number of teeth with lesions or restorations

Abscess

Recognized by a clear drainage passage leading from the tooth row(s) to the external surface of either maxilla or mandible; data recorded in two fields.

Two numeric characters for the total number of sockets examined

One numeric character for the total number of abscesses

Data Collection

The health index incorporates the length of life and physical health while living, in order to produce an overall health score for the population being assessed. The calculation of the health index has three key characteristics: it is multi-attribute, it grades lesions or skeletal deficiencies by severity, and it is adjusted for the distribution of ages

found at sites (Steckel et al., 2002:147). The Western Hemisphere Health Index protocol requires the analysis of skeletal remains using the naked eye under good lighting.

Doran and Dickel assessed the age and sex of individuals within the Windover population at the time of excavation. Age was determined based on dental seriation, skeletal and dental development, and epiphyseal closure. Age was adjusted per the WHHI protocol. Sex was determined using standard osteologic traits such as pelvic and cranial morphology.

Crania were examined first and scored for porotic hyperostosis and cribra orbitalia. Many of the crania within the population were reconstructed from highly fragmented remains at the time of excavation, making assessment for porotic hyperostosis challenging using macroscopic techniques.

Dentition was also scored at this time. This included recording the number of teeth present, the number of teeth lost antemortem, the number of abscesses, the number of carious lesions, and the presence and rate of enamel hypoplasias. Carious lesions, as well as enamel hypoplasias can be difficult to score for the Windover population due to extreme dental attrition affecting the majority of the population.

The postcranial skeletal elements were scored next. The presence of infectious lesions, trauma, and degenerative joint disease was assessed and recorded for all individuals meeting the WHHI protocol concerning presence of required elements. Stature was calculated using maximum femur length and regression formulas for Native Americans (Scuilli et al., 1990:275-280).

The individuals from Windover were examined under the designated conditions and scores were recorded within an Excel spreadsheet. Individual scores can be found in Appendix A.

Once the scores were complete, the results were forwarded to Anna Kjellstrom, a doctoral candidate at the Osteoarchaeological Research Laboratory at Stockholm University, Sweden. The scores were tabulated (see Steckel and Rose, 2002, Chapter 3 for computer program criteria) and the overall scores were then integrated into the Western Hemisphere Health Index scores.

Environmental Classification

The health index classifies sites according to nine ecological variables that include the location of the site, ancestry of its inhabitants, subsistence practices (including animals and plants), the vegetation, topography, and elevation of the site, and climate. The variables are assigned so that sites can be defined geographically, ancestrally, and according to means of subsistence. The categories are provided below.

Table 2.2 Definition of Ecological Variables (Steckel and Rose, 2002).

Location

    1 North America, southeast

    2 North America, Great Lakes

    3 North America, mid-continent

    4 North America, coastal

    5 North America, southwest

    6 Meso-America

    7 South America, mountain

    8 South America, western coastal

    9 South America, eastern coastal

Ancestry

    1 Native American

    2 Euro-American

    3 Afro-American

    9 Afro-American slave

Subsistence Animals

    1 No Domesticates

    2 New World

    3 New and Old World Mix

Subsistence Plants

    1 No domesticates

    2 Some domesticates

    3 Maize (Potatoes), beans, squash

    4 New and Old World Mix

Vegetation

    1 Forest

    2 Open Forest

    3 Grassland

    4 Semi-Desert

Topography

    1 Major River Flood Plain

    2 Coastal

    3 Plains

    4 Rolling (low hills)

    5 Mountain

Climate

    1 Tropical

    2 Subtropical

    3 Temperate

    4 Subtemperate

    5 Arctic

Elevation

    1 Sea level to 100 meters

    2 100 to 300 meters

    3 300 to 1000 meters

    4 1000 to 3000 meters

    5 3000+ meters

Settlement Pattern

    1 Mobile

    2 Settled dispersed

    3 Small/Medium Village

    4 Paramount Village/Town

    5 Urban

Windover is categorized as a Native American population from southeastern North America. They inhabited subtropical grasslands along the major river flood plain of the St. Johns. The site was near sea level and they had neither domesticated animals or plants.

CHAPTER 3 - RESULTS

Windover Scores

Once the skeletal remains were scored according to the Western Hemisphere Health Index and the data were amassed, their overall scores were calculated. The first section of the chapter will present overall scores from the Windover population. These scores will then be incorporated into the entire database and compared to other populations within the set. The Windover scores are presented in Table 3.1.

Table 3.1 Overall health index scores for the Windover population.

Group	Qual	%of max	Stature	Hyp.	Anem.	Dent.	Infec.	DJD	Trauma	Pers. Years
Total	18.05	68.4	24.5	39.5	85.2	89.4	77.5	87.0	76.0	13457

The distribution of percent of maximum scores for the entire WHHI database, including the Windover population, are provided in Figure 3.1. The maximum score possible for all categories is 100%, with the exception of Quality scores, which have a maximum score of 26.38. Low scores represent high rates of pathology being assessed.
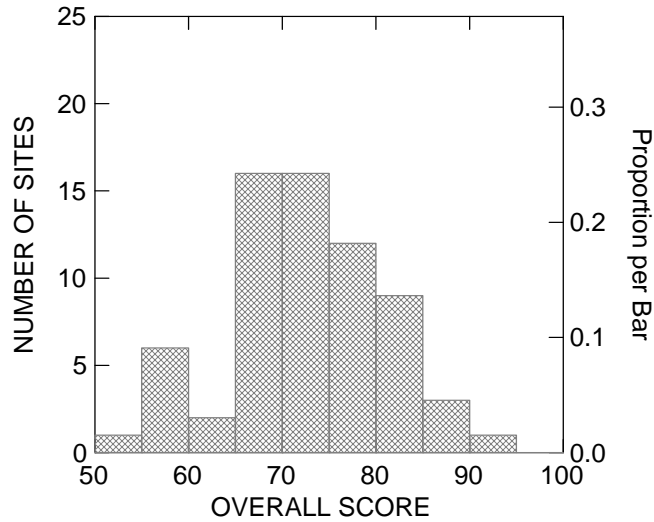
Figure 3.1 Distribution of maximum health scores for the WHHI (Windover = 68.4%).

The quality score, which is out of a maximum of 26.38, is provided below in Figure 3.2 for the entire dataset, including Windover.
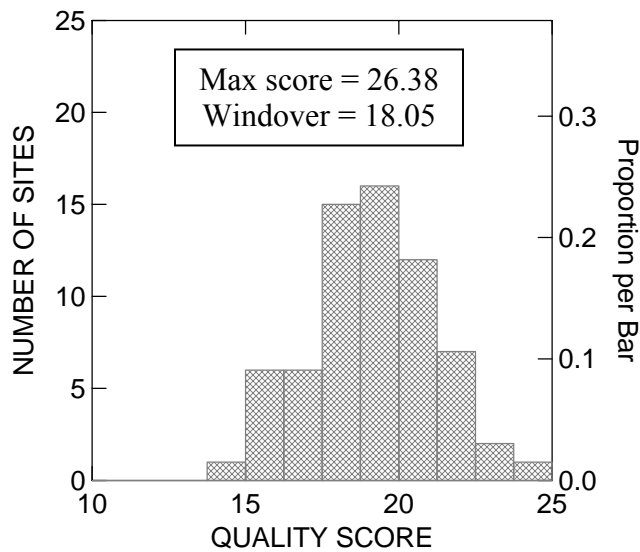
Figure 3.2 Overall quality scores for all sites.

Windover Dental Attributes

       The raw numbers for dental attributes include the total number of permanent teeth present, the number of permanent teeth lost antemortem, the total number of teeth with carious lesions, the number of sockets examined and the total number of abscesses of those individuals included in the present study. They are provided in Table 3.2.

Table 3.2 Dental attribute counts.

Total # Permanent Teeth Present	Permanent Teeth Lost Antemortem	Total # Teeth w/ Carious Lesions	Total Sockets Examined	Total Abscesses
2293	186	118	2849	80
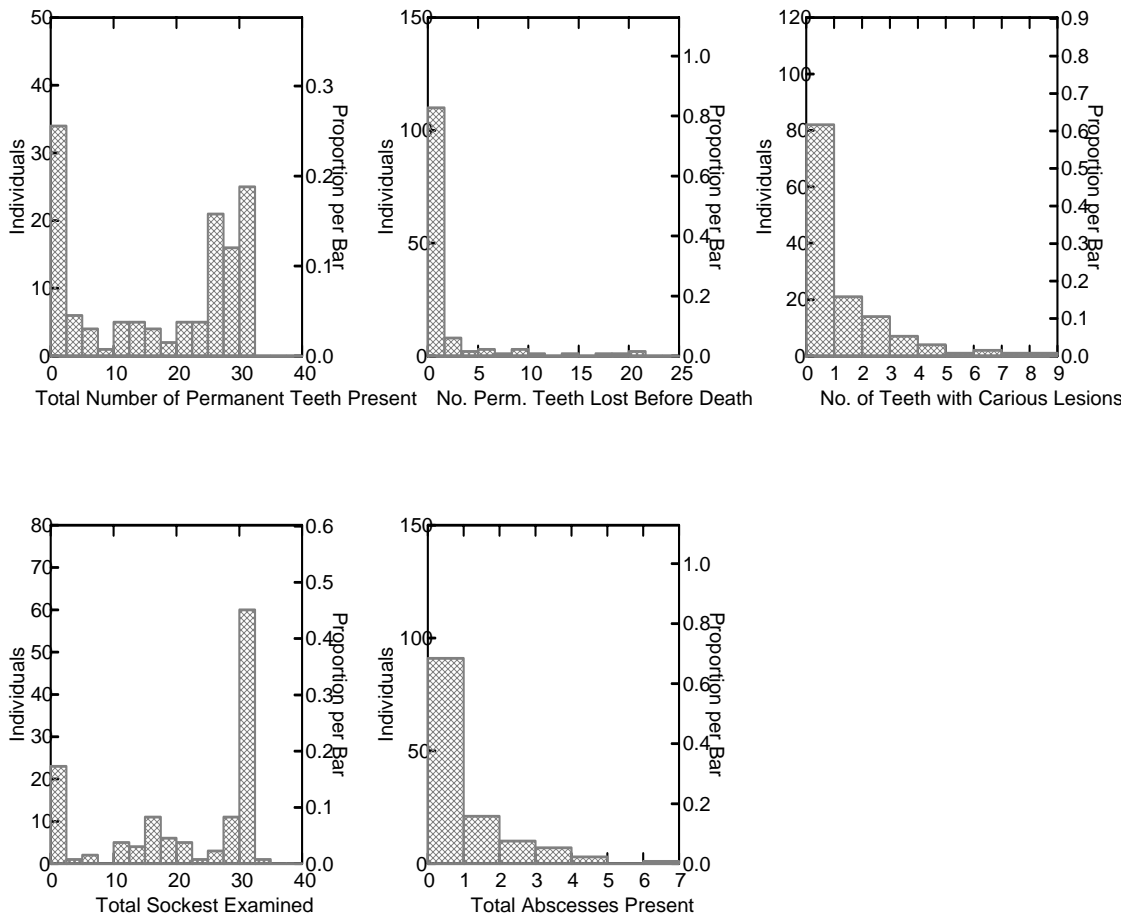
Figure 3.3 Dental attributes and counts from the Windover population.

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The dental remains from Windover are well preserved and numerous. Attrition rates were high among the population, probably secondary to high levels of grit in the diet and extramasticatory behavior. Subadults experienced moderate rates of attrition of deciduous dentition prior to permanent tooth eruption. There has been convincing evidence linking increased wear to fewer carious lesions (Larsen, 1997; Milner, 1984; Corbett and Moore, 1976). Thus, the total number of carious lesions was likely affected by the heavy rates of attrition within the population. Windover had an overall dental health score of 89.4%, ranking within the top 1/3rd of the WHHI sample.
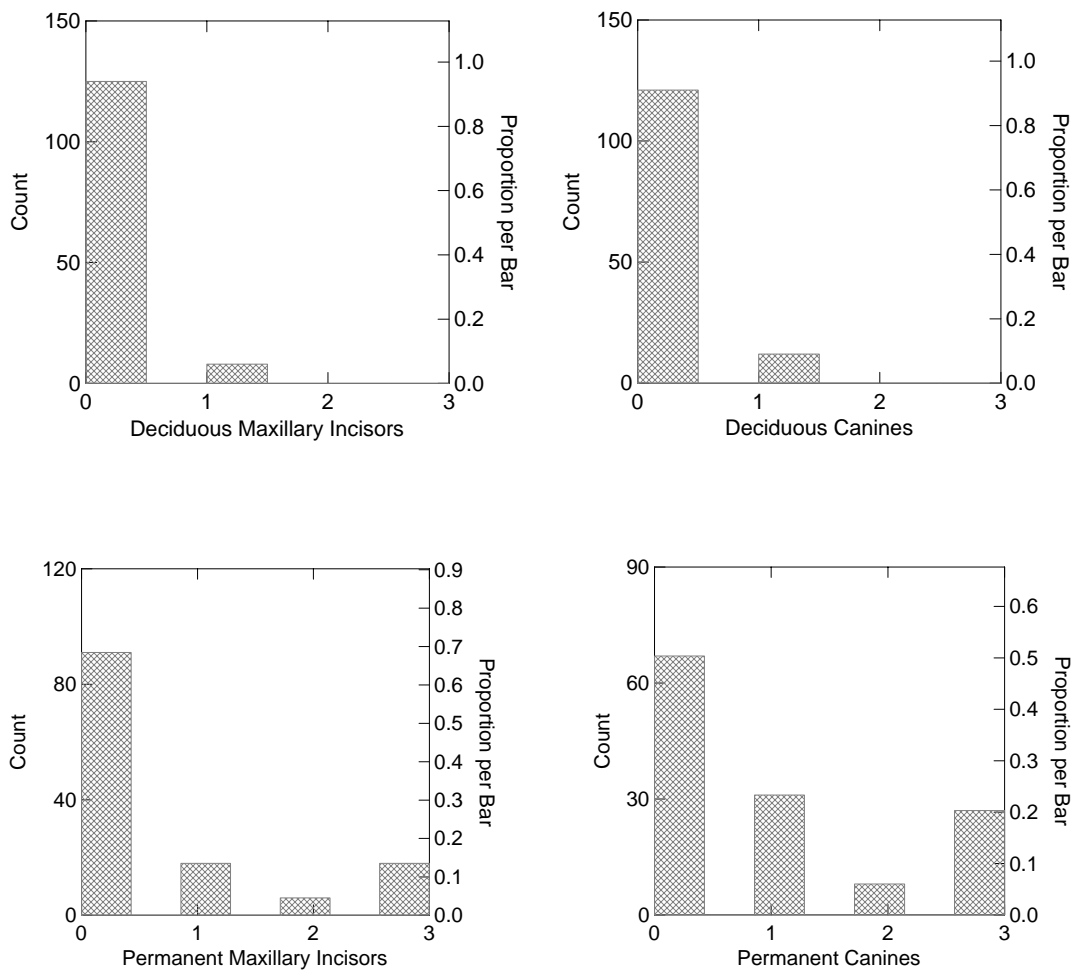
Figure 3.4 Enamel hypoplasia counts for deciduous and permanent dentition from the Windover population.

Enamel hypoplasias are useful indicators of systemic growth disturbances during childhood and are routinely used to investigate patterns of morbidity and mortality in past populations (King et al., 2005). Windover had an overall low enamel hypoplastic defect score (39.5%), indicating periods of biological stress during developmental years. However, the periods of stress occurred after deciduous dentitions were fully formed, since defects occurred only on permanent teeth.
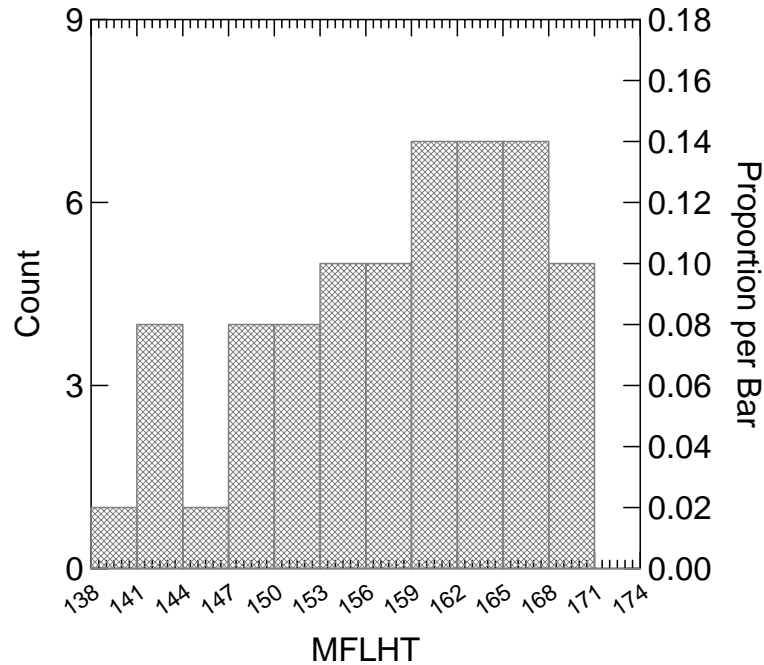
Figure 3.5 Stature distribution from the Windover population based on maximum femur length.

Stature was based on maximum length of the femur and calculated based on regression formulae for Native Americans from Scuilli et al. (1990:275-280), per WHHI protocol. Windover had an overall low stature score (24.5%) yet placed in the top half of the total sites surveyed due to extremely low scores from other sites within the data set. The highest recorded score was 67.8%. Low stature scores may be secondary to poor preservation of longbones.
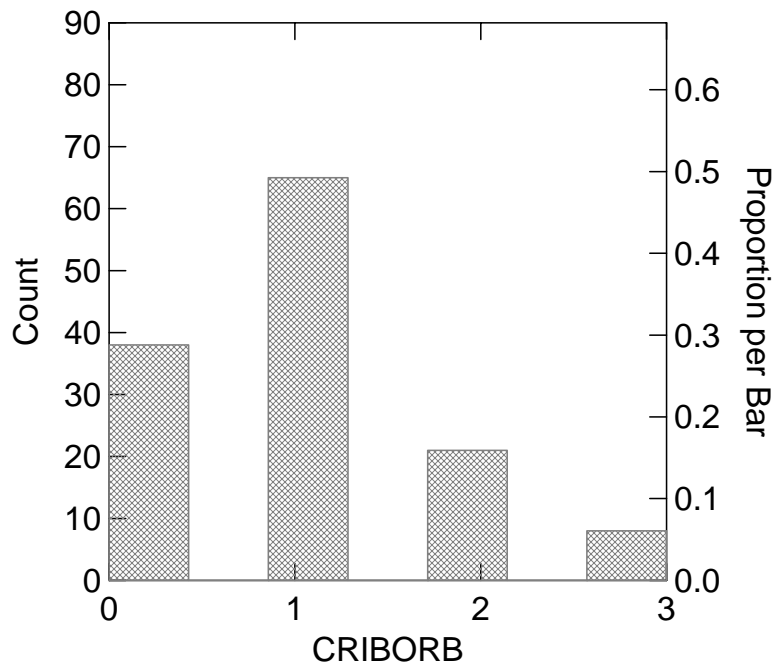
Figure 3.6 Cribra orbitalia scores for the Windover population.

<u>Cribra Orbitalia</u>

   0) No orbits observed
   1) Absent on at least one observable orbit
   2) Presence of a lesion
   3) Gross lesions with excessive expansion and large area of exposed diploe
       (form associated with sickle cell anemia and other forms of severe anemia)

Out of 133 individuals, 94 had orbits available for scoring. Sixty-five individuals had orbits with no lesions. The remainder (29) exhibited cribra orbitalia lesions of varying degrees, with 21 exhibiting the presence of a lesion and eight exhibiting gross lesions associated with sickle-cell disease and other severe forms of anemia.
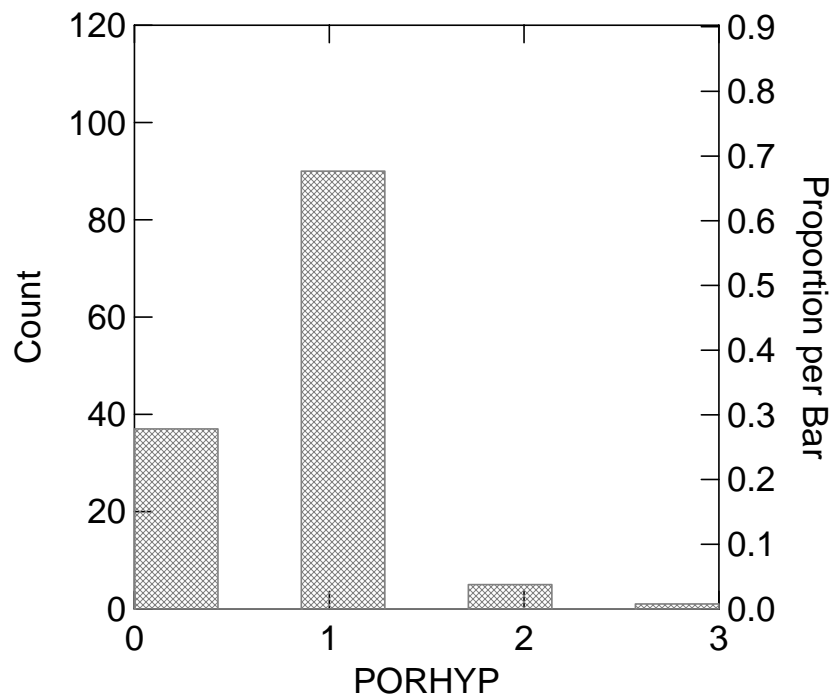
Figure 3.7 Porotic hyperostosis scores for the Windover population.

<u>**Porotic Hyperostosis**</u>

   0) No parietals to be observed
   1) Absent on at least one observable parietal
   2) Presence of a lesion
   3) Gross lesions with excessive cranial expansion and huge areas of exposed diploe
      (form associated with sickle cell and other forms of anemia)

   The incidence of porotic hyperostosis was less frequent than that of cribra orbitalia. Ninety individuals had parietals available for assessment yet exhibited no porotic hyperostosis. Five individuals exhibited lesions, with only a single individual exhibiting gross lesions with excessive cranial expansion associated with sickle-cell disease and other severe forms of anemia. The assessment for porotic hyperostosis was complicated by the reconstruction and use of consolidant on the majority of crania within the population.
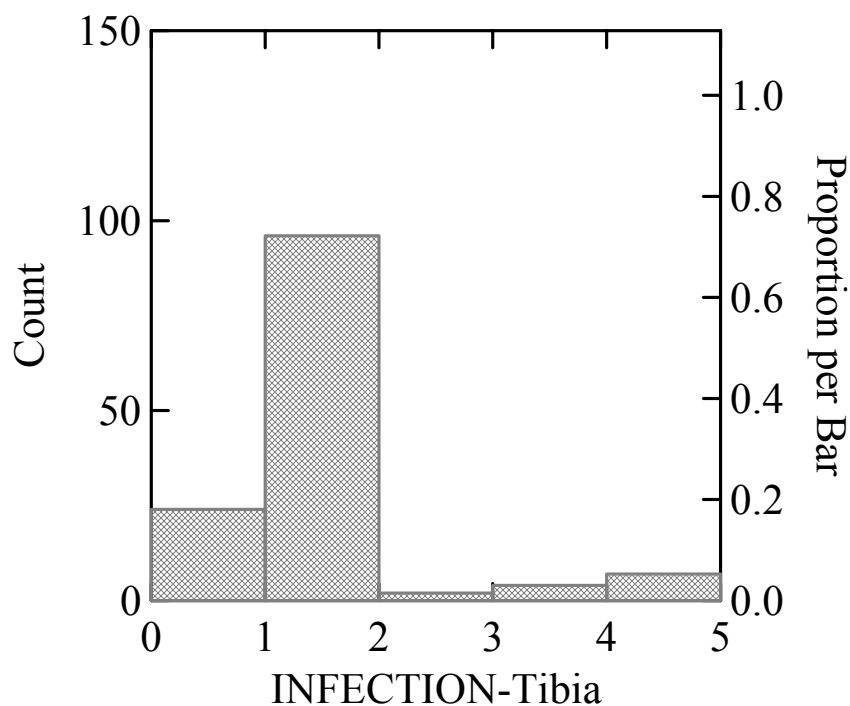
Figure 3.8 Infection of the tibia scores for the Windover population.

Tibial Infection

   0) No tibia(e) present for scoring
   1) No infections lesions of the tibia(e) with at least one tibia available for scoring
   2) Slight, small discrete patch(es) of periosteal reaction involving less than one-quarter of the tibia(e) surface on one or both tibiae
   3) Moderate periosteal reaction involving less than one-half of the tibia(e) surface on one or both tibiae
   4) Severe periosteal reaction involving more than one-half of the tibia(e) surface (osteomyelitis is scored here)

Twenty-four individuals did not have tibiae available for scoring. Ninety-six had tibiae present showing no sign of infection. Two individuals exhibited small patches of periosteal reaction involving less than one-quarter of the surface of one or both tibiae and four had moderate involvement with less than one-half of the surface involved. Seven individuals exhibited severe periosteal reaction involving more than one-half of the tibial surface.
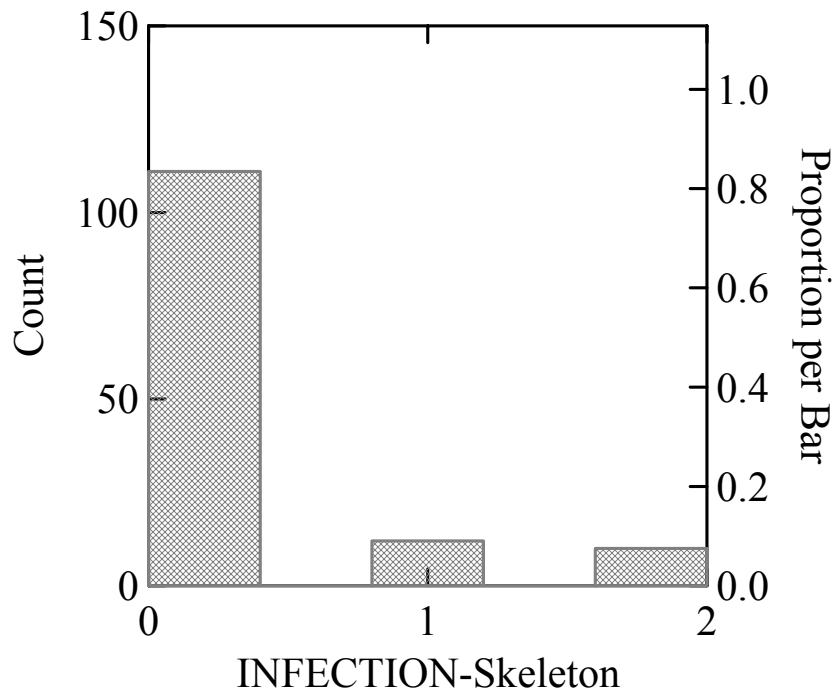
Figure 3.9 Infection scores for the remainder of the skeleton for the Windover population.

Skeletal Infection Scores

0) No periosteal reaction on any other bone than the tibiae
1) Periosteal reaction on any other bone(s) than the tibiae not caused by trauma
2) Evidence of systemic infection involving any of the bones (including the tibiae) of the skeleton. This would include specific diseases, such as (but not limited to) tuberculosis and syphilis.

One hundred and eleven individuals exhibited no periosteal reaction on any bone other than the tibia. Twelve individuals exhibited periosteal reaction on bones other than the tibia, not caused by trauma and ten showed sings of systemic infection, with multiple bones exhibiting periosteal reaction. No individuals exhibited patterned involvement indicative of particular disorders such as tuberculosis or treponemal disease. Table 3.3 provides the percentages of bones exhibiting infection and number of bones observed.

Table 3.3 Bones affected by infection within the Windover population.

	Tibia	Remainder of Skeleton
Elements Affected/Elements Observed	12/108	21/133
Percent Affected	11%	15%
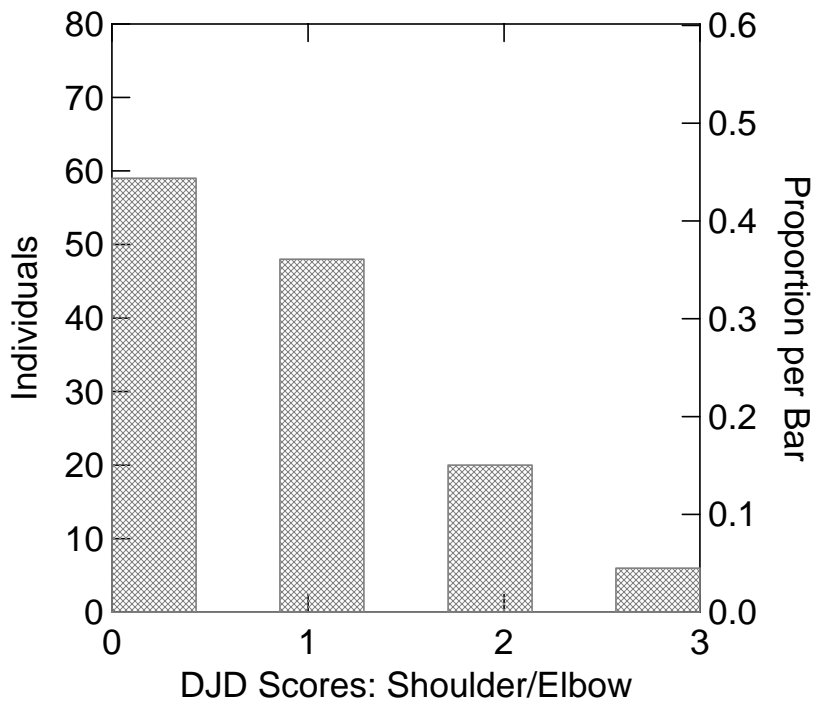
Figure 3.10 Degenerative joint disease scores for the shoulder and elbow from the Windover population.

Shoulder and Elbow

0) Joints not available for observation
1) Joints show no sign of degenerative disease
2) Initial osteophyte or deterioration of the joint surfaces
3) Major osteophyte formation and/or destruction of the joint surface, such as eburnation
4) Immobilization of the joint due only to degenerative disease
5) Systemic degenerative disease (e.g. rheumatoid arthritis)

Forty-eight individuals had shoulder/elbow joints available for scoring, yet exhibited no signs of degenerative joint disease. Twenty individuals exhibited initial osteophyte formation or deterioration of the joints surfaces, while only 6 individuals exhibited major osteophyte formation or destruction of the joint surface. None of the individuals exhibited immobilization of joints or evidence of systemic disease.
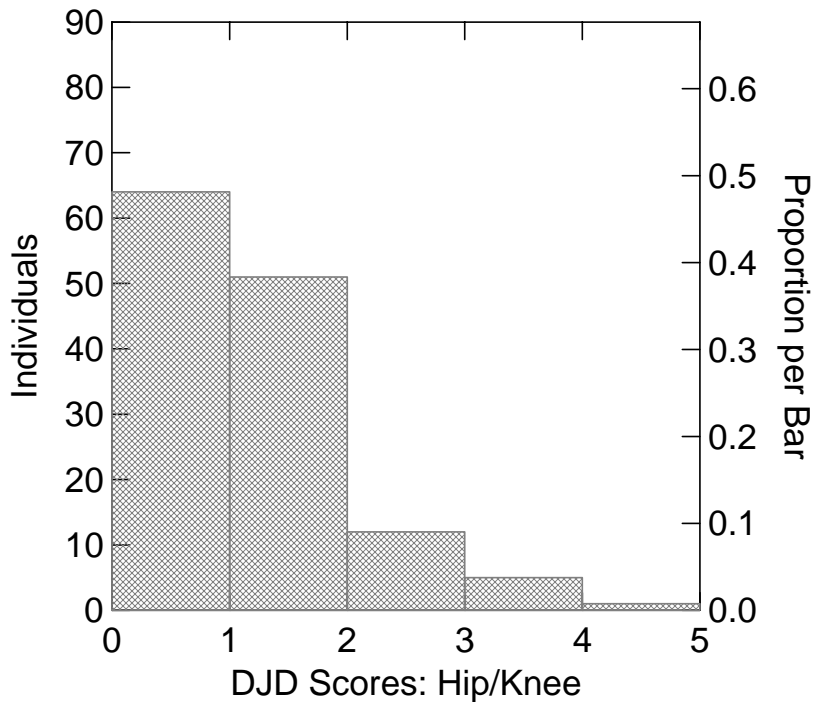
Figure 3.11 Degenerative joint disease scores for the hip and knee for the Windover population.

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Hip and Knee (scored as one unit)

0) Joints not available for observation
1) Joints show no sign of degenerative disease
2) Initial osteophyte or deterioration of the joint surfaces
3) Major osteophyte formation and/or destruction of the joint surface, such as eburnation
4) Immobilization of the joint
5) Systemic degenerative disease

Sixty-five individuals lacked the combination of joints available for scoring. Fifty-one individuals had joints available for scoring yet exhibited no signs of degenerative joint disease. Eleven individuals exhibited initial osteophyte formation or deterioration of the joint surfaces, while five individuals exhibited major joint destruction or osteophyte formation. Only one individual exhibited immobilization of a joint and no individuals exhibited systemic disease.
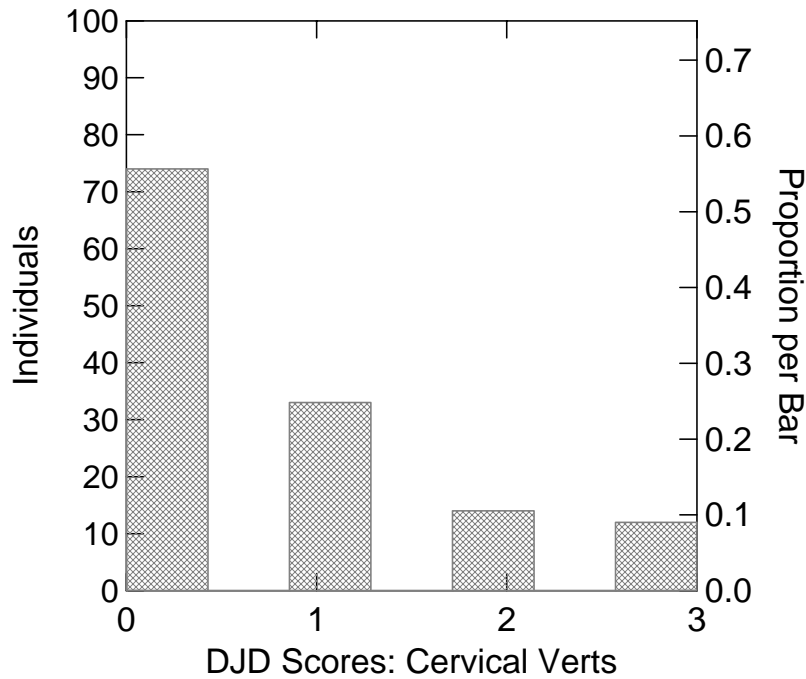
Figure 3.12 Degenerative joint disease scores for cervical vertebrae for the Windover population.

<u>**Cervical**</u>

0) Not observable
1) No lesions on at least two observable vertebrae
2) Initial osteophyte formation along rim of vertebral body(ies)
3) Extensive osteophyte formation along rim of vertebrae
4) Two or more vertebrae fused together

Vertebrae were scored by type (cervical, thoracic, and lumbar). There must be four or more thoracic and two or more cervical or lumbar present for the individual vertebrae to be assessed. Only the bodies of the vertebrae are scored for the most severe expression.

Seventy-four individuals did not meet the criteria for available vertebrae for scoring. Thirty-two individuals showed no signs of degenerative joint disease of the cervical vertebrae, while fourteen exhibited initial and twelve extensive osteophyte formation.
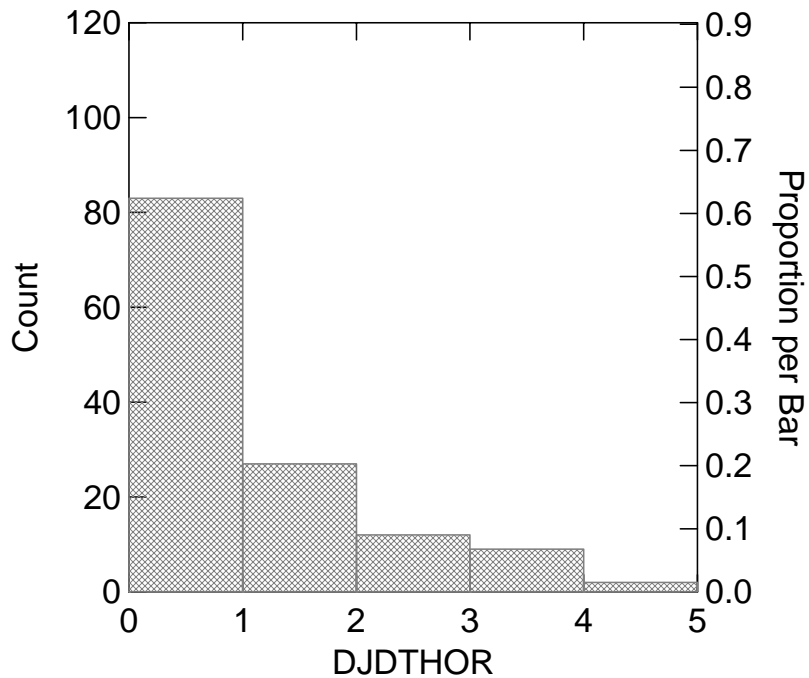
Figure 3.13 Degenerative joint disease scores for thoracic vertebrae for the Windover population.

Thoracic

0) Not observable
1) No lesions on at least four observable vertebrae
2) Initial osteophyte formation along rim of vertebral body
3) Extensive osteophyte formation along rim of vertebrae
4) Two or more vertebrae fused together (kyphosis from TB scored under infectious disease)

Eighty-three individuals did not have four or more thoracic vertebrae available for scoring. Twenty-seven showed no lesion formation, 12 exhibited initial osteophyte formation, and nine had extensive osteophyte formation. Two individuals had two or more vertebrae fused together.
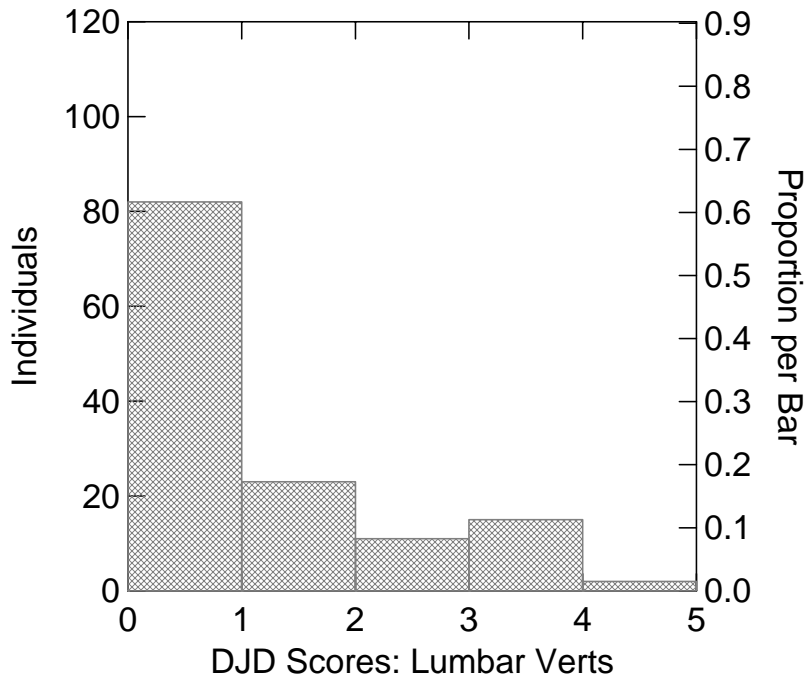
Figure 3.14 Degenerative joint disease scores for lumbar vertebrae for the Windover population.

<u>Lumbar</u>

0) Not observable
1) No lesions on at least two observable vertebrae
2) Initial osteophyte formation along rim of vertebral body(ies)
3) Extensive osteophyte formation along rim of vertebrae
4) Two or more vertebrae fused together

Eighty-two individuals lacked two or more thoracic vertebrae available for scoring. Twenty-three individuals exhibited no lesions on at least two observable vertebrae. Eleven individuals exhibited initial osteophyte formation while 15 had extensive formation along the rim of the vertebral bodies. Only two individuals exhibited fusion of two or more vertebrae.
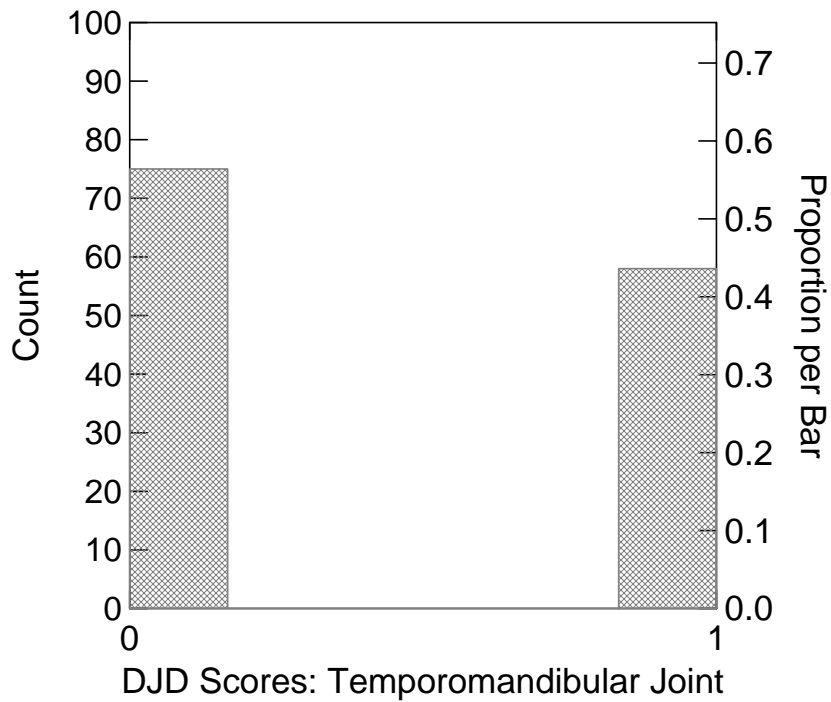
Figure 3.15 Degenerative joint disease scores for the temporomandibular joint for the Windover population.

Temporomandibular Joint

0) TMJ not observable
1) No deterioration
2) Joint deterioration

Only extreme deterioration of the temporomandibular joint is recorded, which includes osteophyte formation, eburnation, or joint surface deterioration. Seventy-five individuals lacked a complete joint for scoring, while 58 individuals showed no signs of deterioration of the joint. There were no cases of degenerative joint disease of the temporomandibular joint among the Windover population.
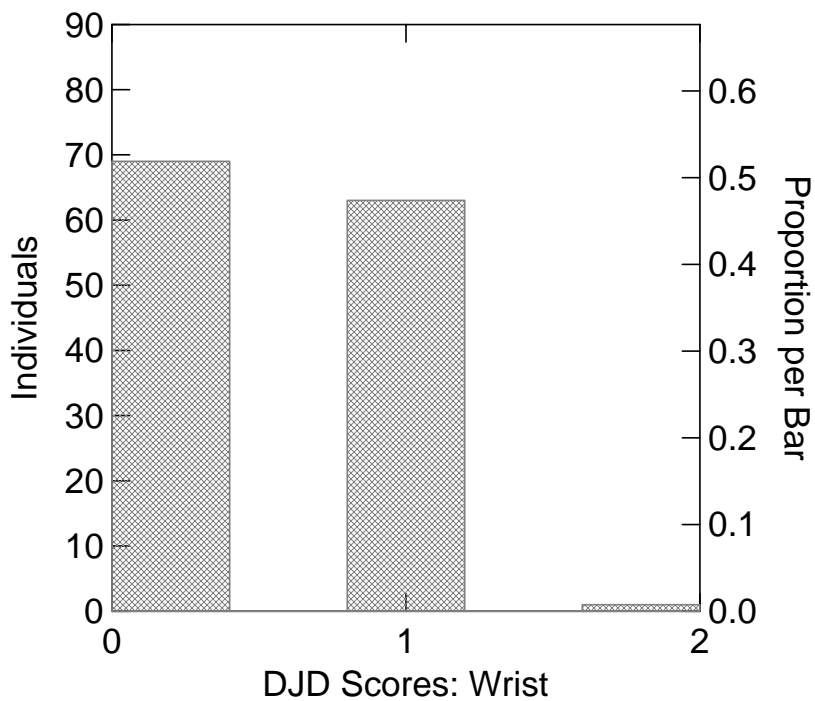
Figure 3.16 Degenerative joint disease scores for bones of the wrist for the Windover population.

Wrist

0) Bones not observable or not recorded
1) No degenerative joint disease
2) Degenerative disease of the joint

Sixty-nine individuals lacked the radio-ulnar joint for scoring. Sixty-three individuals showed no signs of deterioration, while only a single individual exhibited degenerative disease of the joint.
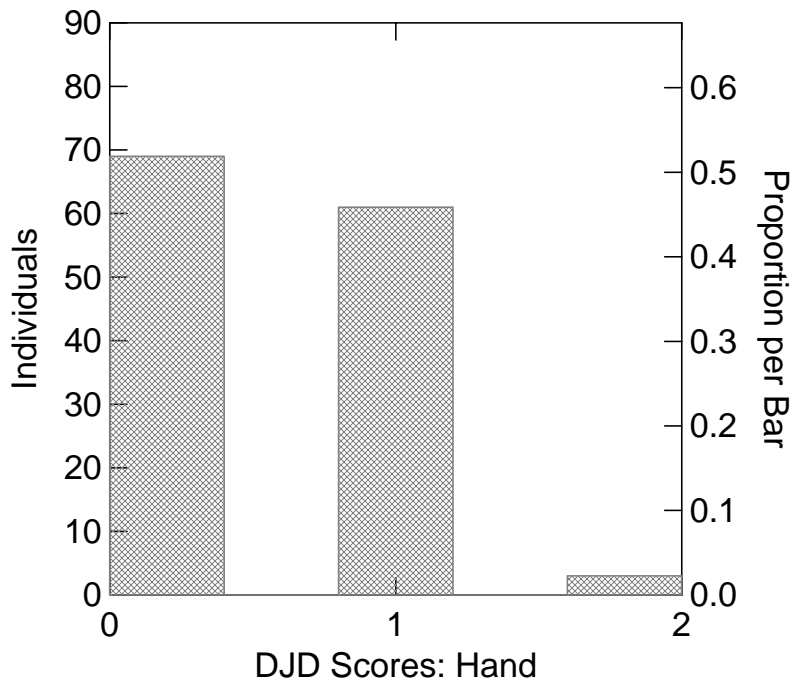
Figure 3.17 Degenerative joint disease scores for bones of the hand for the Windover population.

Bones of the Hand

0) Bones not observable or not recorded
1) No degenerative disease of the joint
2) Degenerative disease of the joint

Sixty-nine individuals lacked hand bones available for scoring. Sixty individuals showed no signs of disease, while only 3 individuals exhibited degenerative joint disease of the bones of the hand. Table 3.4 provides a breakdown in number of joints observed and number affected.

Table 3.4 Joints affected by degenerative joint disease in the Windover population.

	Shoulder/ Elbow	Hip/ Knee	Cervical Vert.	Thoracic Vert.	Lumbar Vert.	TMJ	Wrist	Hand
Joints Affected/Joints Observed	24/72	17/68	24/58	22/49	27/50	0/57	1/63	3/63
Percent Affected	33%	25%	41%	44%	54%	0%	1%	4%

Vertebrae showed the highest incidence of degenerative joint disease. Although degenerative joint disease can be indicative of mechanical load and bending/torsion injuries, it is also highly correlated with normal age-related changes. Considering the large number of individuals within the Windover population above the age of 40 (47), the elevated number of vertebrae involved could simply be a reflection of normal degenerative changes present in an elderly population. This could also be the case with degenerative changes of the shoulder/elbow and hip/knee. Activity-related changes will be discussed at the end of the chapter.
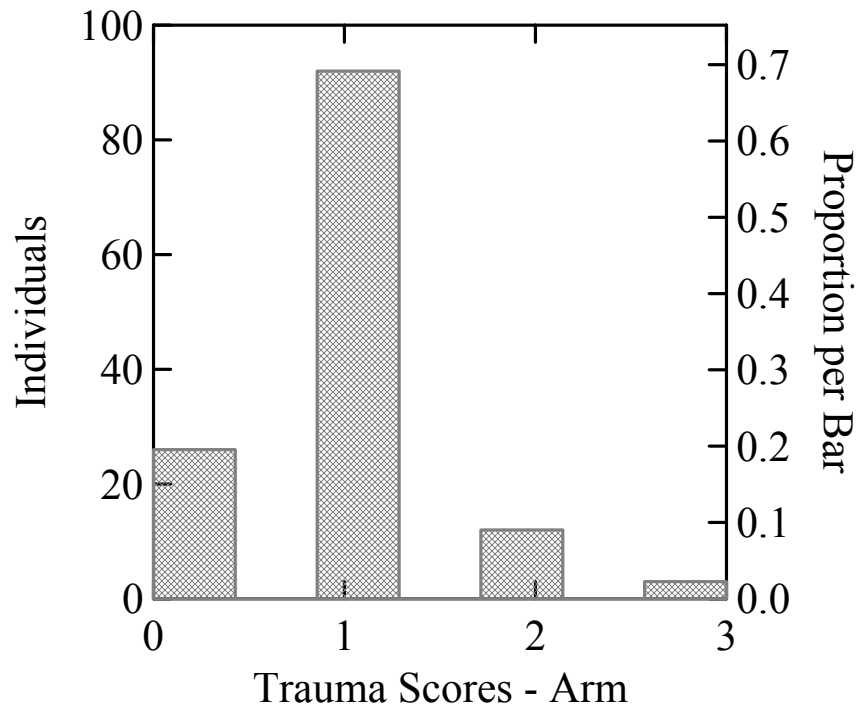
Figure 3.18 Arm trauma scores for the Windover population.

Arm

  0) No long bones observable
  1) Not fractured
  2) Healed fracture with acceptable alignment
  3) Healed and poorly aligned
  4) Healed with fusion of the joint
  5) Healed fracture with alignment unknown

   Trauma of the arm included assessment of the humerus, radius, and ulna, although an individual must have a humerus and at least one bone of the forearm present to be evaluated. Twenty-six individuals did not meet the criteria for inclusion in the assessment. Ninety-one exhibited no trauma of the upper arm. Twelve individuals exhibited healed fractures with acceptable alignment, while three individuals exhibited poorly aligned fractures.
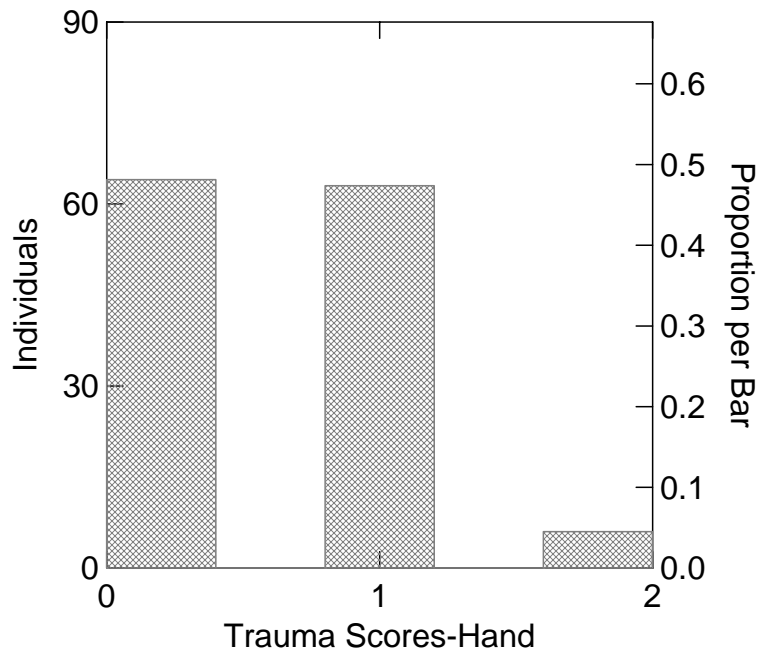
Figure 3.19 Hand trauma scores for the Windover population.

Hand

0) No bones to be observed or not recorded
1) No fracture
2) Healed fracture(s)

Sixty-four individuals had no hand bones available for assessment. Sixty-three exhibited no fractures, while six individuals exhibited healed fractures of the hand.
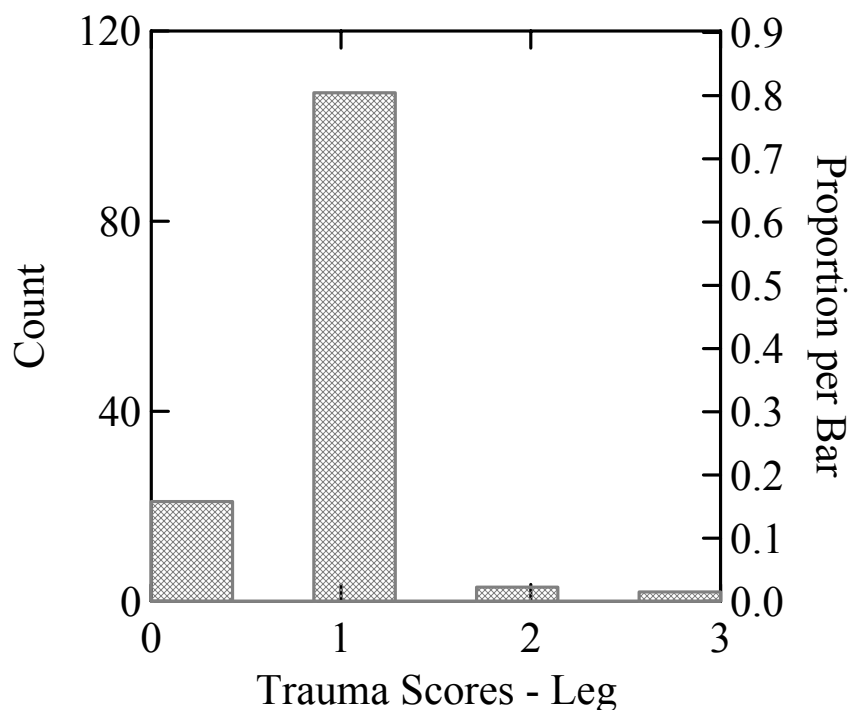
Figure 3.20 Leg trauma scores for the Windover population.

Leg

0) No long bones observable
1) No fracture or trauma
2) Healed fracture with acceptable alignment
3) Healed and poorly aligned with some loss of locomotion
4) Healed with extreme loss of locomotion, such as loss of limb or complete fusion of joint in lower limb
5) Healed with alignment unknown

Assessment of trauma to the leg includes the femur, tibia, and fibula. An individual must have a femur and at least one bone of the lower leg to be included in the analysis. Twenty-one individuals did not meet the criteria for inclusion in the analysis. One hundred and seven individuals exhibited no fractures. Three exhibited healed and acceptably aligned fractures, while two individuals exhibited poorly aligned fractures of the leg. No individuals exhibited injuries that would have caused extreme loss of locomotion or complete fusion of a lower limb joint. All fractures were assessed for alignment.

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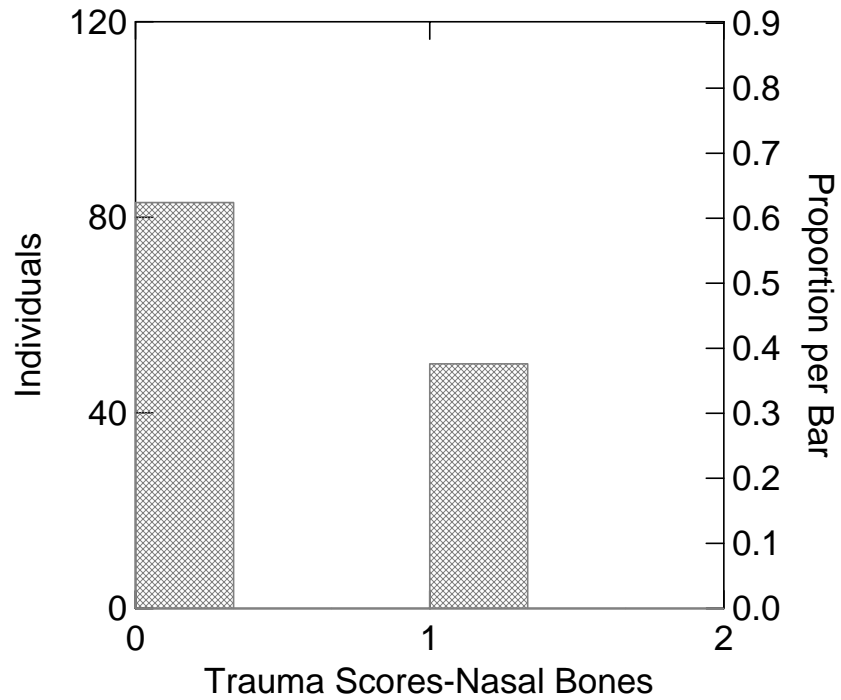
Figure 3.21 Nasal bone trauma scores for the Windover population.

<u>**Nasal and Nasal Process**</u>

0) No bones to be observed
1) No fracture
2) Healed fracture

Although only 53 of the 133 individuals had nasal bones present for scoring, none exhibited fractures of the nasal bones or nasal process.
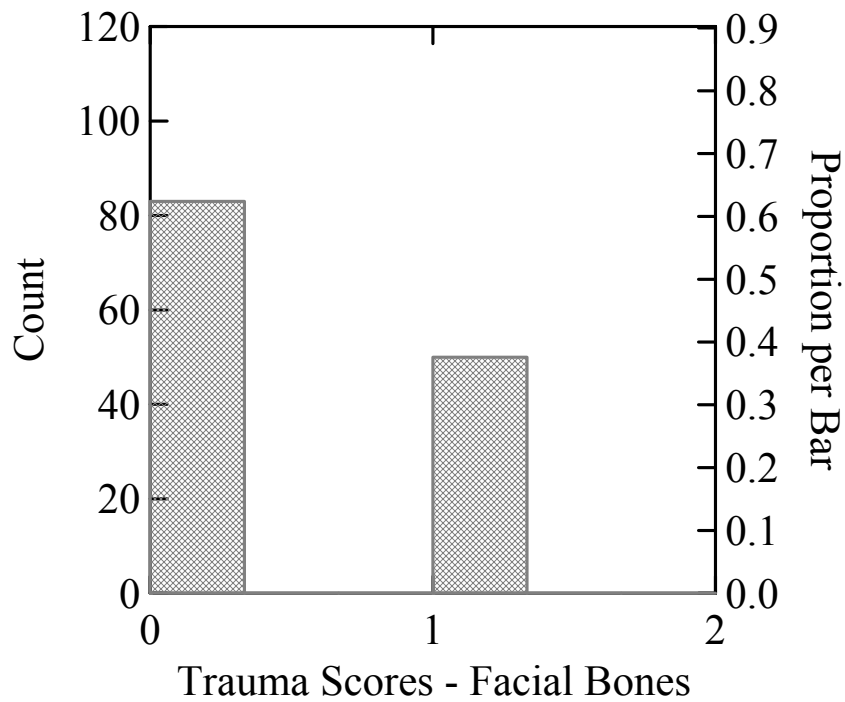
Figure 3.22 Facial trauma scores for the Windover population.

<u>**Face Other than Nasal**</u>

0) No bones to be observed
1) No fracture
2) Healed fracture

Eighty-eight individuals lacked facial bones, other than nasal bones, to be assessed. Forty-four individuals exhibited no fractures of the facial bones, while a single individual exhibited a fracture of the orbit.
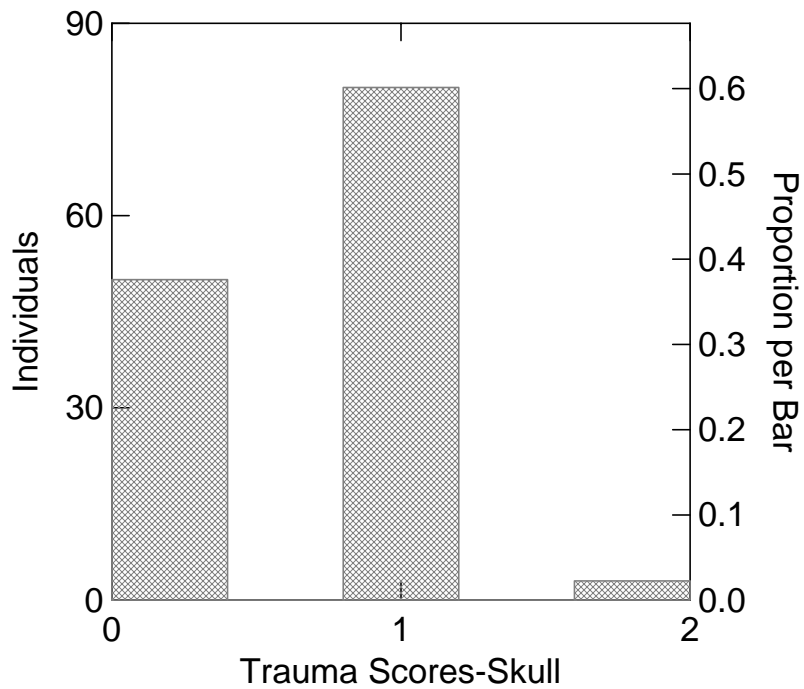
Figure 3.23 Cranial trauma scores for the Windover population.

<u>**Skull Vault**</u>

0) No bones to be observed
1) No fracture
2) Healed fracture

Fifty individuals lacked cranial bones for trauma assessment of the skull. Eighty individuals exhibited no cranial fractures, while three individuals exhibited healed, depressed cranial fractures. Table 3.5 provides a breakdown in number of bones observed and affected by trauma.

Table 3.5 Bones affected by trauma among the Windover population.

	Arm	Leg	Nasal	Face	Skull	Hand
Bones Affected/Bones Observed	14/106	4/111	0/49	1/44	3/82	6/68
Percent Affected	13%	3%	0%	2%	3%	8%
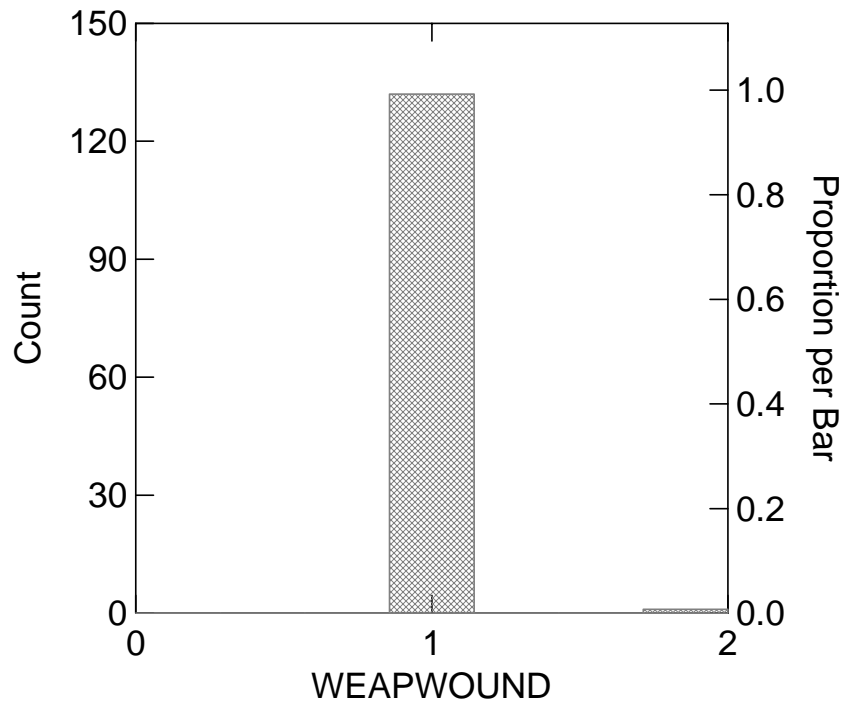
Figure 3.24 Weapon wound scores for the Windover population.

<u>**Weapon Wounds**</u>

1) No weapon wounds
2) Weapon wound(s)

Weapon wounds were assessed for all parts of the body and head. Out of 133 individuals, only one individual exhibited a weapon wound in the form of a bone point embedded in the hip.

Comparison of Windover to the Western Hemisphere Health Dataset

Once the scores were calculated for the Windover population, they were incorporated into the overall scores for all 65 sites within the Western Hemisphere Health dataset. The following graphs display the distribution of scores for skeletal indicators utilized by the health index (maximum score for each indicator = 100%).
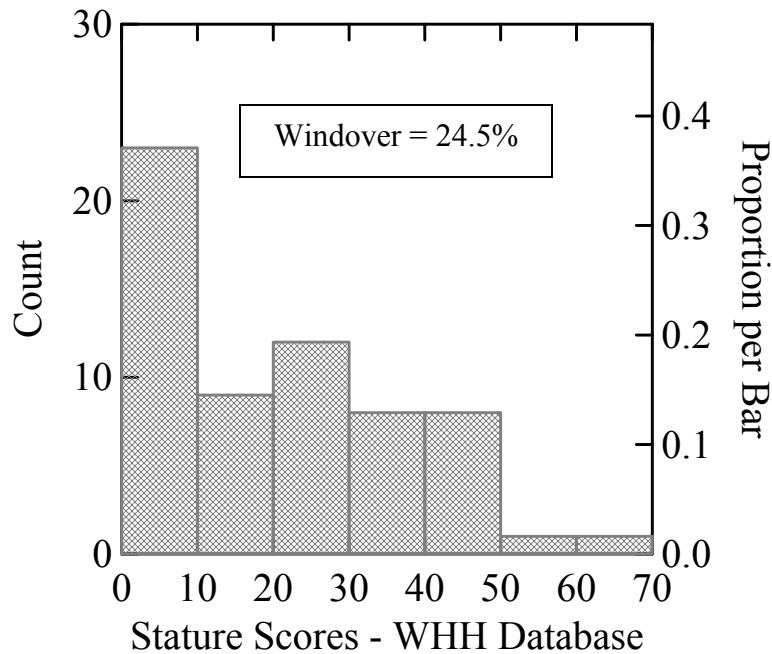
Figure 3.25 Stature score distributions for the WHH Database.
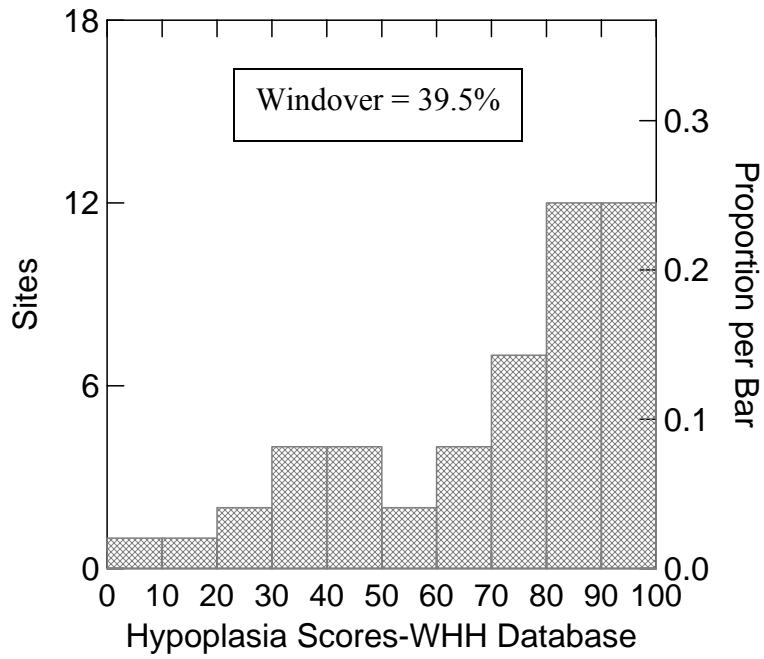
Figure 3.26 Hypoplastic scores for the WHH database.
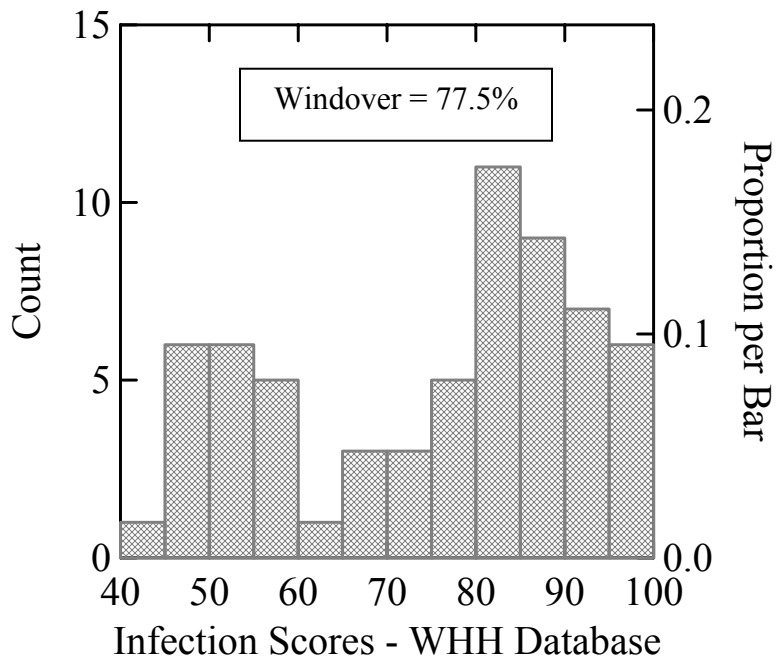
Figure 3.27 Infection scores for the WHH database.
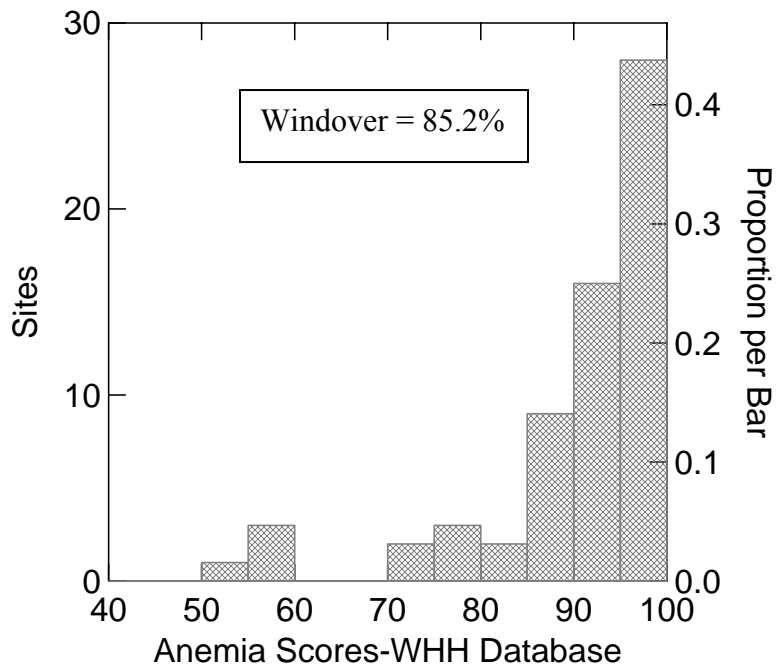
Figure 3.28 Anemia scores for the WHH database.
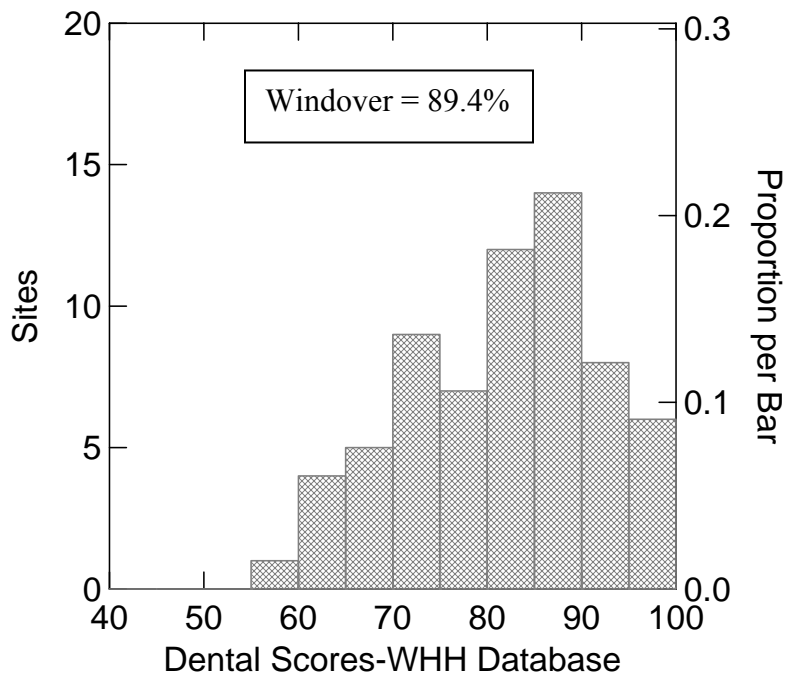
Figure 3.29 Dental scores for the WHH database.
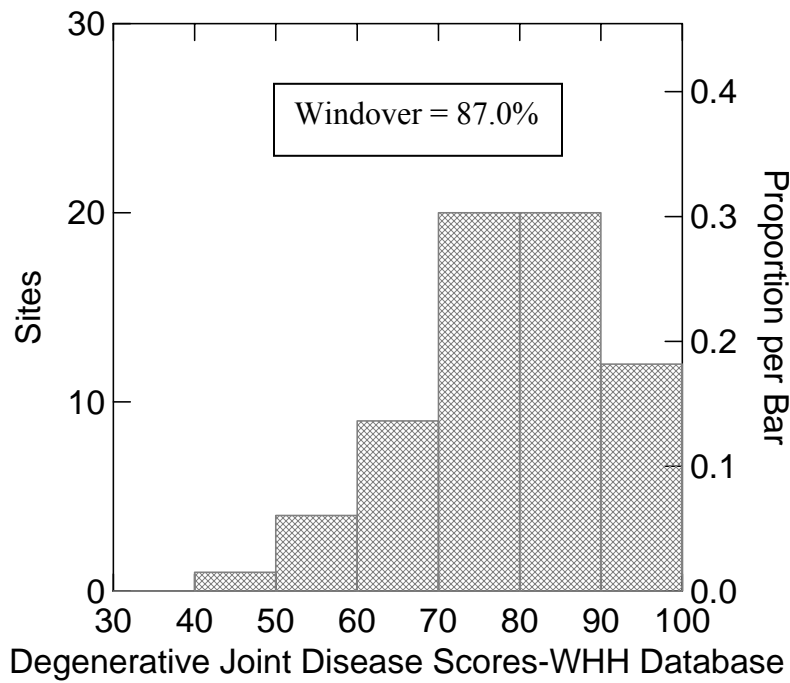
Figure 3.30 Degenerative joint disease scores for the WHH database.
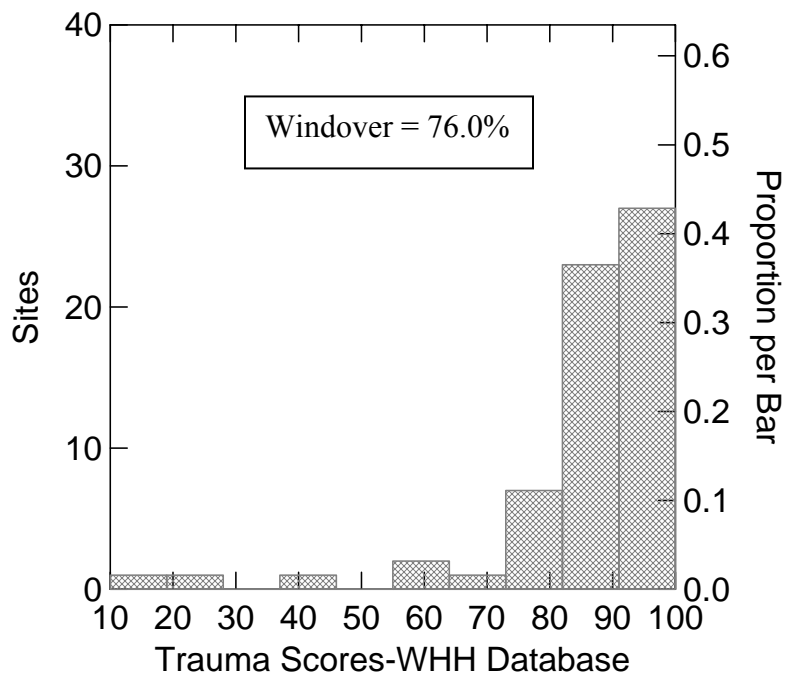
Figure 3.31 Trauma scores for the WHH database.
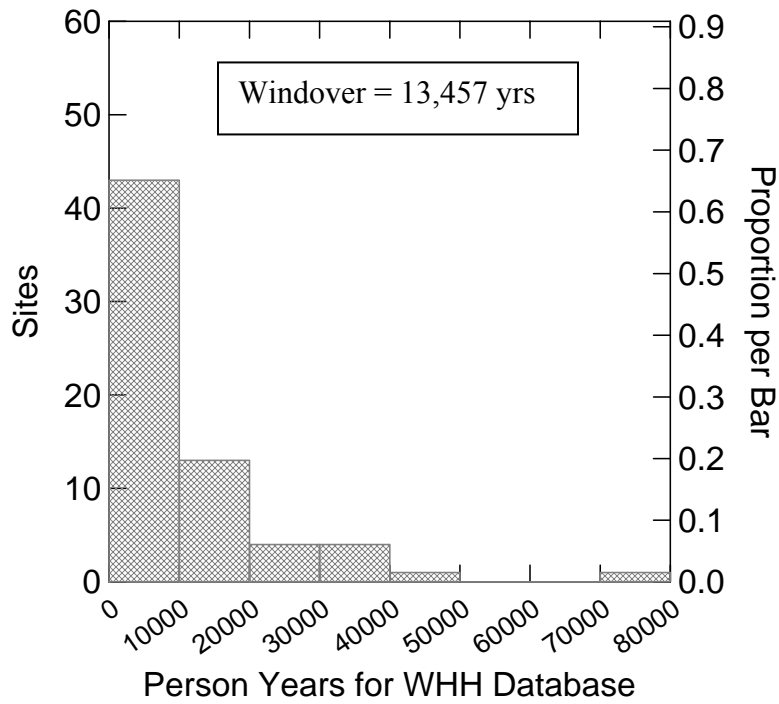
Figure 3.32 Person years for all WHHI sites.

Table 3.6 provides a comparison of the medians and means of health index scores compared to those of the Windover population.

Table 3.6 Windover scores compared to medians and means of WHHI dataset.

	QUAL	% of MAX	STAT	HYPO	ANEM	DENT	INFEC	DJD	TRAU
8BR246	68.4	18.0	24.5	39.5	85.2	89.4	77.5	87.0	76.0
Pop Median	72.7	19.1	17.9	75.4	94.2	83.0	80.1	79.8	89.2
Pop Mean	72.5	19.1	20.7	70.4	90.4	81.8	75.1	79.0	85.5

Differential Health Among Windover Males and Females

According to Kjellstrom, scores within the index are typically not calculated based on sex due to inadequate sample sizes of males and females within many sites. Windover, however, had adequate representations among the sexes (35 females, 43 males) to accommodate score calculations based on sex. Table 3.7 presents overall health scores among males and females from Windover.

Table 3.7 Health scores among males and females from Windover.

Group	Qual	%of max	Stature	Hyp.	Anem.	Dent.	Infec.	DJD	Trauma	Pers. Years
Total Population	18.05	68.4	24.5	39.5	85.2	89.4	77.5	87.0	76.0	13457
Males	18.16	66.8	26.1	37.3	94.3	89.8	82.7	85.5	69.7	6675
Females	17.24	65.4	23.5	40.0	76.3	87.0	66.5	90.3	73.8	4716

Males had higher overall scores than females in six out of nine categories. Males out-scored females in overall quality of life, percent of maximum scores, stature, anemia, dental disease, and infection. Males also had overall higher number of person years for the index, but this could be due to the larger sample of males within the population (43 males vs. 35 females). Females out-scored males in enamel hypoplasia and degenerative joint disease.
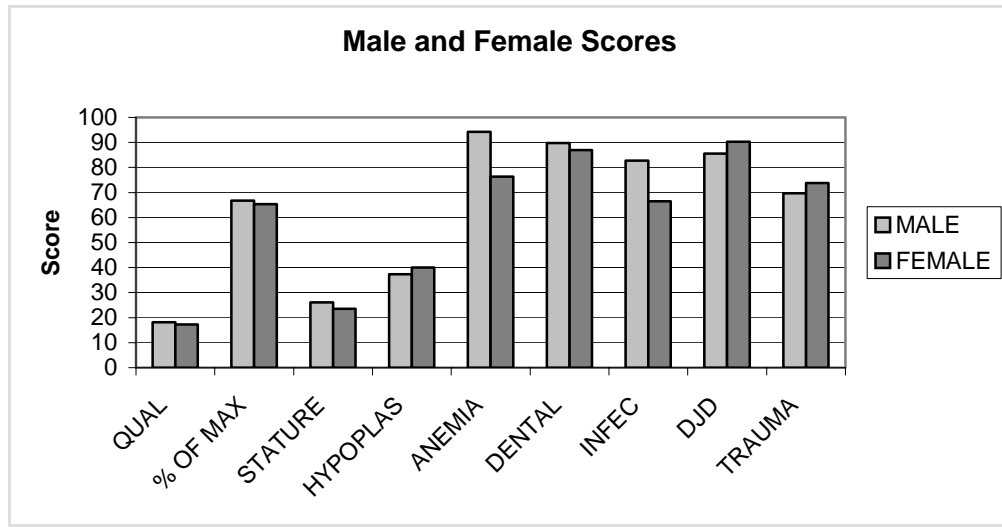
Figure 3.33 Skeletal indicator scores for males and females from Windover.

Trauma scores were slightly lower among males (difference of 4.1%), reflecting higher incidences of traumatic injury compared to females. In a previous analysis of fracture frequencies among the people from Windover (Smith, 2003) involving a larger sample size from the population, males and females exhibited similar numbers of fractures, with the majority of injuries being accidental in nature. Neither sex exhibited fracture patterns indicative of interpersonal conflict, such as multiple injuries in combination with fractures of the face or head. Although fractures of the ulna were frequent (15 total) and parry fractures have been linked to interpersonal conflict (Zivanovic, 1982; Ortner and Putschar, 1981; Larsen, 1982; Byers, 2002), none of the individuals displayed patterned injuries suggesting intentional injury. The higher incidence of traumatic injury among the males at Windover could merely reflect higher levels of activity, such as increased travel distances and hazards associated with food procurement. Fracture frequencies (number of fractures per number of observable elements) and percentage of each element fractured are provided below in Table 3.8.

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Table 3.8 Fracture frequencies and percentages for males and females from Windover (frequencies are provided as number of fractures/elements observed).

	Arm	Leg	Nasal	Face	Skull	Hand
Male	7/40	1/40	0/22	1/18	3/27	2/32
	17%	2%	0%	5%	11%	6%
Female	6/30	3/33	0/14	0/11	0/28	4/26
	20%	9%	0%	0%	0%	15%
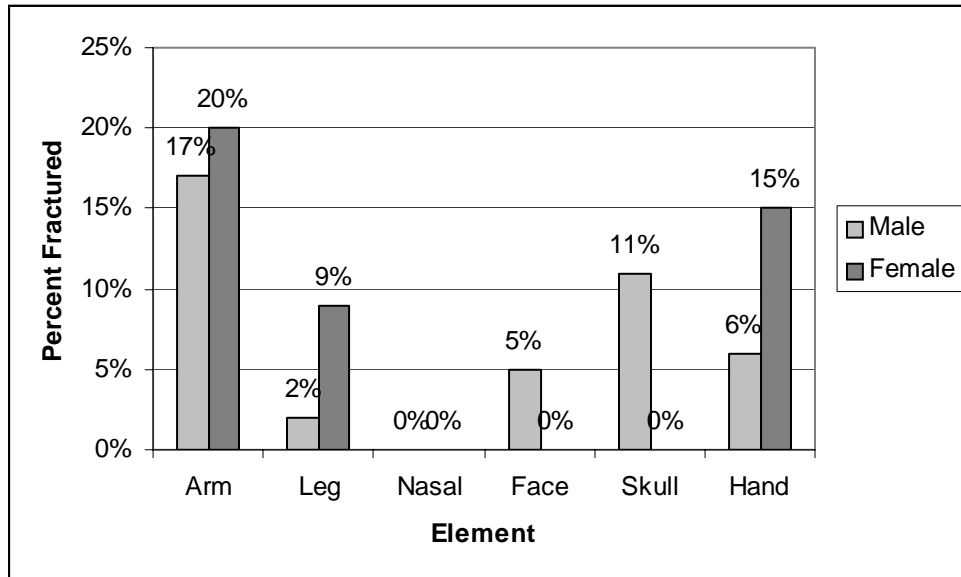
Figure 3.34 Percents of elements fractured among males and females from Windover.

Arm trauma prevailed as the most common form of injury, predominantly as ulnar fractures. Although females had slightly higher incidences, an earlier study indicated they were the result of accidental injury, not related to interpersonal violence (Smith, 2003). Females lacked fractures of the face and skull yet had significantly more trauma to the bones of the hands. Molleson (1994) linked traumatic alteration of toe joints among the

females of Abu Hureya to physical demands associated with grinding grain while kneeling. The high rate of hand fractures among the females of Windover could possible be associated with the processing of hides or plant foods, work traditionally delegated to females. High rates of facial and skull trauma have been linked to interpersonal conflict, yet the males from Windover lacked associated evidence of such conflict (Smith, 2003). Overall trauma scores for the Windover population were significantly lower compared to the rest of the WHHI dataset (Windover trauma score of 76.0 compared to total dataset mean of 85.5). Exceptional preservation could account for the elevated number of documented fractures. Yet the low scores attest to the physical challenges inherent to Florida's Archaic period.

Degenerative joint disease scores were high for both sexes, compared to the rest of the populations within the database (Windover males 85.5, females 90.3; total dataset mean score of 79.00; median score of 79.85). Males had a slightly lower score, which could be indicative of greater activity levels, as reflected in trauma scores as well. The ratios of joints affected by DJD compared to the number of joints observed, as well as the percentage of joints affected are provided below in Table 3.9.

Table 3.9 Ratios of joints affected and percentage involvement of males and females from Windover (ratios are provided as number of joints affected/joints observed).

	Shoulder/Elbow	Hip/Knee	Cervical Vert.	Thoracic Vert.	Lumbar Vert.	TMJ	Wrist
Male	12/41 29%	12/40 30%	17/35 48%	13/29 44%	19/32 59%	0/26 0%	0/36 0%
Female	12/30 40%	6/26 23%	9/22 40%	10/20 50%	9/18 50%	0/26 0%	2/25 8%
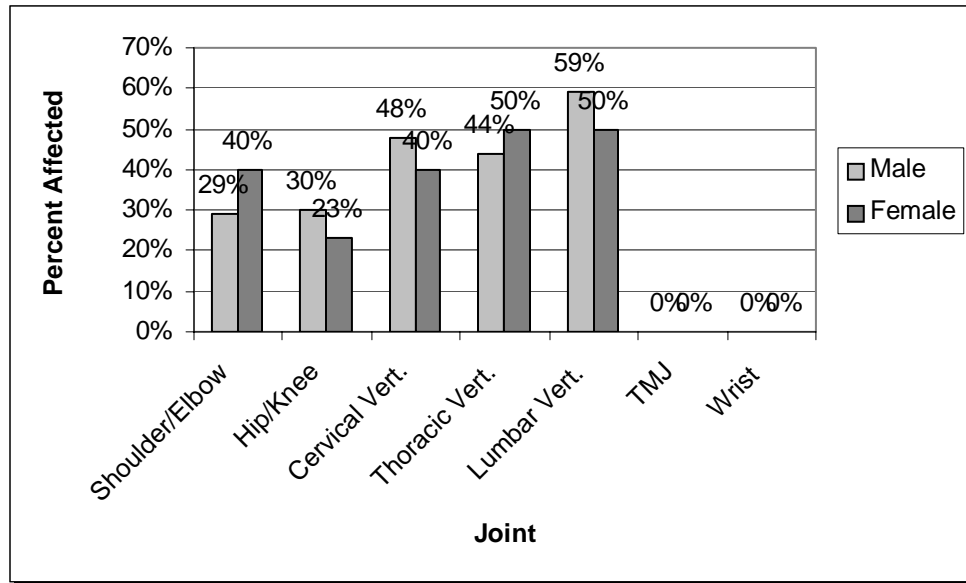
Figure 3.35 Percentage of joints affected by degenerative joint disease among males and females at Windover.

The highest rates of degenerative joint disease, among both sexes, affected the vertebrae. In reviewing relatively modern vertebral columns, Nathan (1962) found that by the third decade of life a large proportion of individuals studied had vertebral osteophytosis, which are early stages of degenerative joint disease; by the fifth decade all of them had the condition (Roberts and Manchester, 1995). The higher rates of DJD affecting shoulders and elbows among the females could, like the increased rates of traumatic injury to the hands, be related to repeated stress associated with food and hide processing. The lack of DJD affecting the wrists of females is curious when considering activity related bone changes. The higher rates of hip and knee DJD among males could be indicative of increased walking associated with hunting activities.

Hypoplasia scores were similar, yet slightly higher in females. Since hypoplastic defects can reflect nutritional status, pathogen load, and metabolic disruptions (Moggi-Cecchi et. al, 1994), this score suggests that males and females experienced similar levels of general health and nutrition during developmental years. Other dental scores reveal discrepancies in health among males and females. Males had a lower incidence of caries (4.5% of teeth affected vs. 6.9% in females), yet had higher numbers of abscesses (4.3% rate vs. 3.2% rate in females) and higher levels of antermortem tooth loss (10.5% of teeth

lost antemortem vs. 7.9% lost in females). Breakdowns of dental scores are provided in Tables 3.10-3.12.

Table 3.10 Carious Lesions among males and females from Windover.

	Total Number of Teeth	Number of Teeth with Carious Lesions	Caries Rate
Males	930	42	4.5%
Females	759	53	6.9%

Table 3.11 Abscess rates among males and females from Windover.

	Total Number of Sockets Examined	Total Number of Abscesses	Rate of Abscesses
Males	768	48	4.3%
Females	1,093	29	3.2%

Table 3.12 Antemortem tooth loss among males and females from Windover.

	Total Sockets Examined	Total Teeth Lost Antemortem	Rate of Tooth Loss
Males	768	115	10.5%
Females	1,093	71	7.9%

Stature scores were higher among males (mean/median of 164 in males vs. mean/median of 150 in females). This suggests that as individuals aged, males may have had access to better diets than females and experienced lower rates of infectious disease and anemia, resulting in greater overall height. Kemkes-Grottenthaler (2005) found correlations between stature and longevity among 2,923 skeletons, with males and females displaying significant inverse relationships between adult height and age at death. Haviland (1967) attributed marked sexual dimorphism in stature partially to genetics but also as a reflection of the relatively lower status for women in Maya society. Holden and Mace (1999) found correlations with stature and contribution to subsistence. Female stature from populations around the world was assessed in order to determine

whether sexual dimorphism is related to the roles each sex plays in food procurement. They found that sexual dimorphism in stature was negatively associated with women's contribution to subsistence, with greater overall female height associated with societies where women contribute more to food production. This is probably due to better overall nutrition among females from such groups with better access to quality foods. Better overall stature among males may have contributed to greater number of person years among the males from Windover. Stature distributions for males and females are provided below in Figure 3.36.
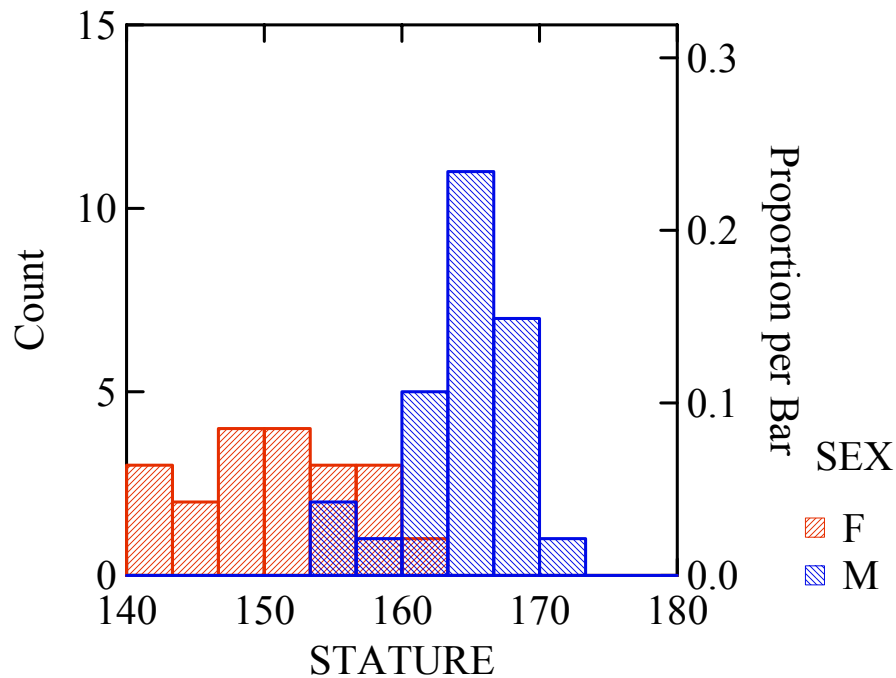
Figure 3.36 Stature distributions for males and females from Windover.

Scores for anemia and infectious disease were significantly lower among females, indicating higher rates of biological stress compared to males. Sullivan (2005) found higher rates of anemia among females interred at the Medieval Gilbertine Priory in York, England, which she associated with chronic anemia from high iron demand reproductive functions. Historic accounts (Engelbrecht, 1987) note the intensive labor demands among Iroquois women, which included carrying heavy loads, processing foods, and caring for

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family. Sofaer Derevenski (2000) noted differential patterns in degenerative joint disease among the sexes at two 16th-19th century sites. At Ensay and the medieval site of Wharram Percy, both in the UK, females exhibited distinct osseous changes due to load bearing of the spine associated with carrying baskets. Slaus (2000) attributed higher frequencies of hypoplasias among females within the Late Medieval population of Nova Raca, Croatia to higher levels of biological stress compared to males. He also attributed significant sex differences among dental pathology to differential access to resources. Tables 3.13 and 3.14 provide incidences of cribra orbitalia and infection of the tibia and remainder skeleton for males and females.

Table 3.13 Rates of cribra orbitalia and percentage frequencies for males and females from Windover.

	Cribra Orbitalia	Porotic Hyperostosis
Male	5/29 17%	2/32 6%
Female	8/29 27%	3/30 10%

Table 3.14 Rates of infection of the tibia and remainder skeleton from males and females from Windover.

	Infection of Tibia	Infection of Remainder of Skeleton
Male	2/39 5%	6/42 14%
Female	3/32 9%	5/35 14%
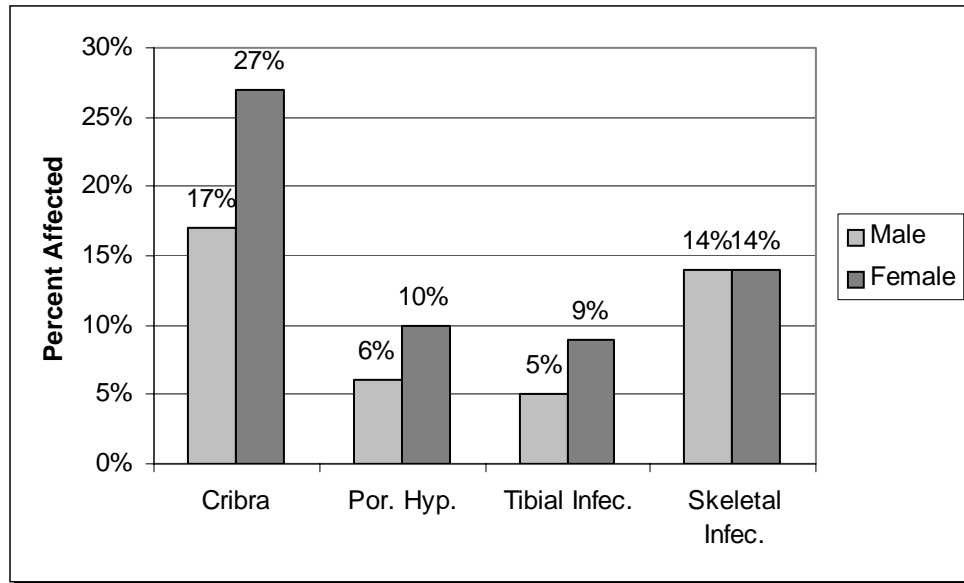
Figure 3.37 Percentage affected by anemia and infectious lesions among males and females from Windover.

Females had significantly higher rates of cribra orbitalia and porotic hyperostosis, both indicators of periods of biological stress. The rates of tibial infection were also higher among females, although skeletal infection was equal among the sexes.

Rosenberg (1980) documented numerous ethnographic accounts that attest to differences among the sexes regarding access to food. Among Old and New World hunter/gatherer populations, male-female dietary discrepancies account for lower life expectancy in females due to limited access to meat (women are traditionally allowed to eat only after males) and food-related taboos that put nutritional limitations on their diets. Higher rates of stress among females from Windover could be linked to diets lacking adequate amounts of protein, diminished resistance to pathogens, as well as the metabolic demands associated with child bearing.

The disparity in scores between the sexes could be indicative of unequal access to resources. If males were given preferential access to higher quality food sources, such as protein, they would be less prone to iron deficiency anemia, therefore exhibiting higher overall scores than females. Prowse et al. (2005) found that females among the Roman population of Isola Sacra, Italy between the 1st and 3rd centuries AD exhibited lower isotopic levels of carbon and nitrogen suggesting, as a whole, they had less access to isotopically enriched marine foods, which are also seen historically to have been higher-

status nutrients. Slaus (2000) noted reduced life expectancy among females in medieval Croatia due to elevated levels of biological stress during life, as indicated by skeletal pathology. Better nutrition would have afforded the males increased resistance to infectious disease, as indicated by higher infection scores. Stature, infection, dental and anemia scores all attest to better overall health of Windover males over females.

To test the hypothesis of diet-related health discrepancy at Windover, Bryan Tucker, a doctoral candidate specializing in stable isotope analysis at the University of Florida, Department of Anthropology, sampled a select group of adult males and females to discern whether variations in isotopic signatures revealed dietary discrepancies. Twenty individuals (10 males, 10 females) from the Windover site were assayed for $\delta^{13}C$ and $\delta^{18}O$ ratios from the mineral (hydroxyapatite) portion of bone (See Appendix A). The organic (collagen) portion of bone was not assayed due to complexities with regard to Rhoplex preservative. Results show no significant differences in diet or area of residence between males and females based on $\delta^{13}C$ and $\delta^{18}O$ values. The sample contains no "extralocal" individuals based on $\delta^{18}O$ values, nor does there appear to be any difference in bulk diet between the sexes. However, three females and one male cluster apart from the other 16 individuals based on their $\delta^{13}C$ values. The differences in diet between the majority of the population and these four individuals may be culturally induced or may represent changes in dietary patterns over the long (ca 1,000 year) use of the site. Figures 3.38-3.40 show oxygen and carbon values for males and females.
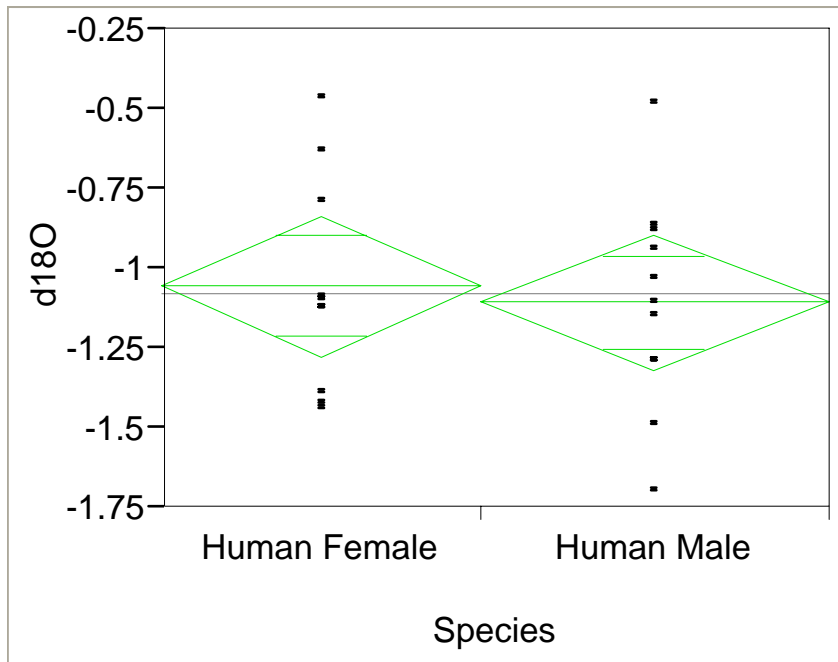
Figure 3.38 d18O values for males and females from Windover.
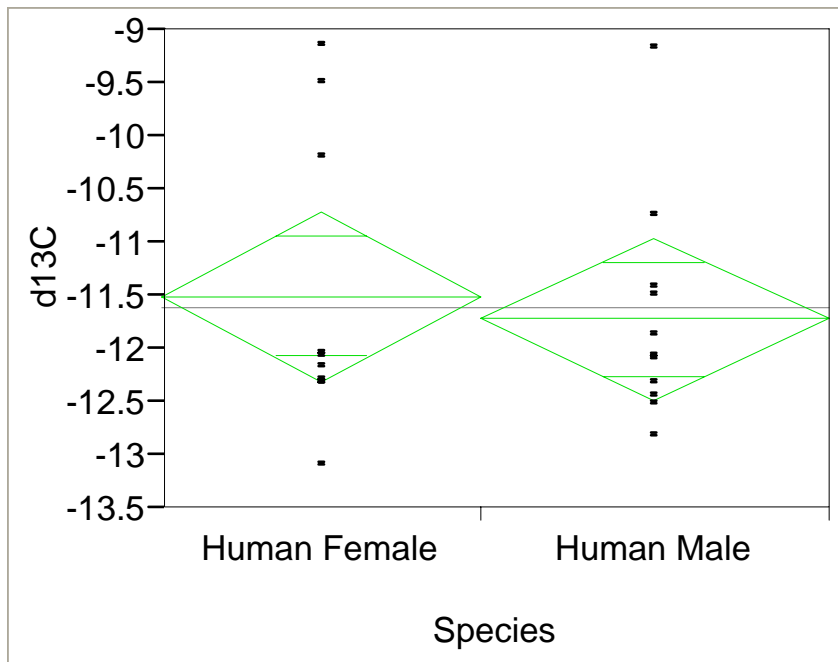
Figure 3.39 d13C values for males and females from Windover.
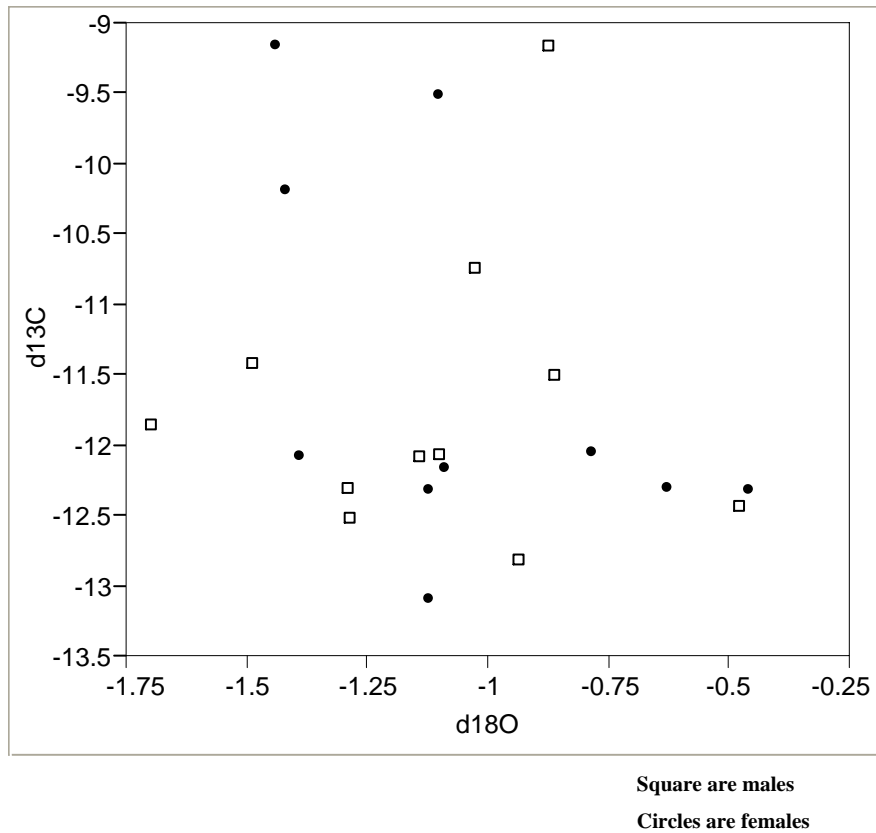
Figure 3.40 Scatterplot of d13C and d18O values for males and females.

Since it appears there was no differentiation in diet based on sex, it appears males and females at Windover were eating the same foods yet whether they had access to equal amounts of these foods is unknown. The disparity in health scores may have been related to the demands of the hunter/gatherer lifestyle in combination with the metabolic demands of childbearing experienced by the females within the group.

CHAPTER 4 - DISCUSSION

The application of the Western Hemisphere Health Index to the Windover population was intended to evaluate the overall health of a hunter-gatherer group and to compare their health scores to those of populations from other geographic areas, practicing different forms of subsistence, during different periods in human history. It was hypothesized that the Windover population would achieve high scores within the index since they were a people predating agriculture by several thousand years, they were not sedentary, and group size remained moderate. Their social structure and subsistence regime would enable them to avoid many of the health problems associated with low-quality maize diets, dense populations and higher pathogen loads inherent in later agricultural, sedentary populations.

In overall quality of life score, the Windover population scored four percentage points below the entire dataset median. In fact, along with overall and percentage of maximum scores, Windover scored below the median in four out of seven of the skeletal indicator categories. These included enamel hypoplasias, anemia, infection and traumatic injury scores. Windover scored above the median in stature, dental health, and degenerative joint disease (See Table 3.6 in Chapter 3).

This chapter will investigate three possible explanations for the low scores of the Windover population:

1. Hunter/gatherer populations do not score consistently high using the Western Hemisphere Health Index as a gauge of overall quality of life.
2. There are problems inherent to the protocol and methodology of the Western Hemisphere Health Index that preclude an accurate assessment of health.
3. The Windover population is idiosyncratic compared to other hunter-gatherer populations within the Western Hemisphere Health Index.

Evaluating the health scores of other preagricultural groups within the index will enable us to see how these populations score as a group. Assessing the scores of populations utilizing similar subsistence practices within similar social structures will enable us to determine whether Windover is unique or typical of hunter/gatherer groups within the dataset.

The ability of the Western Hemisphere Health Index to assess quality of life will be analyzed by evaluating the methodology employed by the index. Factors such as interobserver error, data collection guidelines, and transparency of score calculation will be assessed to critique the protocol and methodology of the index.

Finally, the possibility that the Windover population is idiosyncratic and atypical of preagricultural populations will be examined by assessing aspects of diet, geographic location, environment, and social structure in order to determine possible causal factors that influenced the group's overall health.

Hunter/Gatherer Health

According to *Paleopathology at the Origins of Agriculture* (Cohen and Armelagos, 1984), preagricultural populations experienced better overall health due to smaller population sizes that inhibited the spread of infectious disease and a more varied diet than later agricultural populations. This premise has been reinforced through numerous studies conducted since its publication (Hutchinson, 2002; Larsen, 1995; Larsen and Ruff, 1991; Milner, 1984; Oxenham et. al, 2005; Steckel et. al, 2002).

Sites within the WHHI are classified according to geographic locations, climate, topography, elevation and age of site. They are also defined based on the presence or absence of domesticated animals and plants. There are a total of eleven preagricultural populations included in the Western Hemisphere Health Index (all analyses include the Windover population). These 11 sites lack domesticated animals and plants. The site abbreviation, percent of maximum score, age, and geographic description of these populations are presented in Table 4.1.

Table 4.1 Preagricultural populations within the Western Hemisphere Health Index.

SITE NUMBER	% of MAXIMUM SCORE	AGE	GEOGRAPHIC DESCRIPTION
111	89.2	1,350 BP	Coastal South Carolina
LNP	87.1	3,000 BP	Shell mounds, Southern Brazil
Osg	83.4	7,425 BP	Sta. Elena, Ecuador
WO7	82.4	1,075 BP	Coastal Southern California
101	80.3	1,350 BP	Coastal South Carolina
W42	80.0	5,250 BP	Coastal Southern California
W38	79.0	3,834 BP	Coastal Southern California
W13	76.3	1,625 BP	Coastal Southern California
W28	75.7	434 BP	Coastal Southern California
W43	69.8	1,359 BP	Coastal Southern California
8BR246	68.4	7,442 BP	Inland Florida

The dates for preagricultural populations within the index span the past 7,000 years, with Windover predating all populations in the dataset. Figure 4.1 provides the temporal distribution and overall scores of these sites.
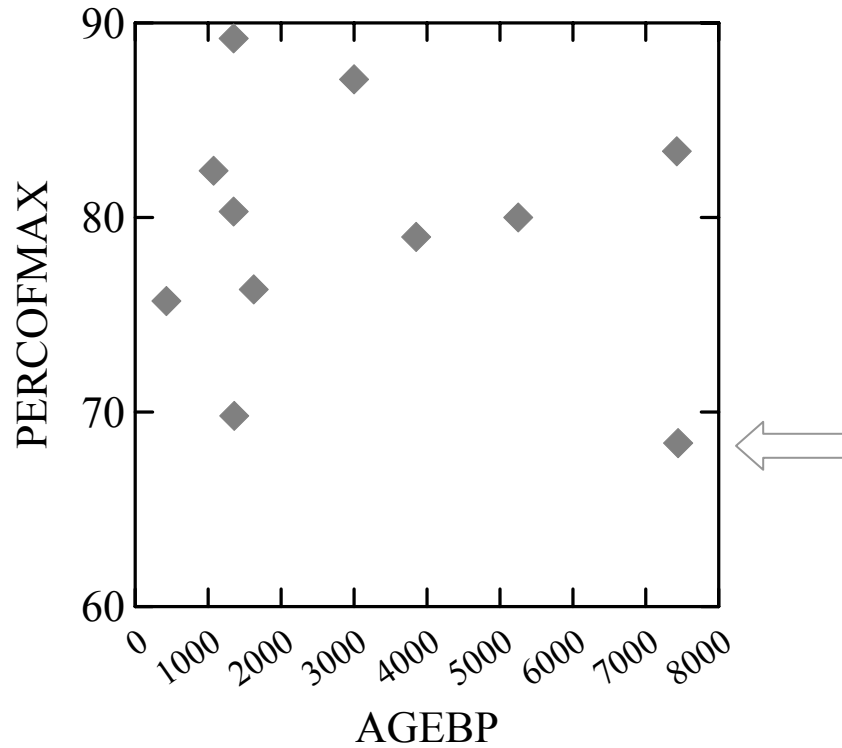
Figure 4.1 Total scores and ages before present for all pre-agricultural groups.

Table 4.2 provides health index scores for all preagricultural populations within the index. Windover scored lowest among all preagricultural populations.

Table 4.2 Comparison of scores for all preagricultural and predomesticate sites.

Site	QALY	% of Max.	Stature	Hyp.	Anemia	Dental	Infec.	DJD	Trauma	Pers Yrs
111	23.54	89.2	59.8	*	98.6	99.9	92.9	91.1	93.2	3764
LNP	22.97	87.1	*	75.4	83.6	87.3	*	98	91.2	9301
osg	22.00	83.4	8.7	99.7	100	91.1	98.7	94.8	90.8	4643
WO7	21.75	82.4	42.8	85	96.1	97.4	83.8	78.6	93.4	30154
101	21.19	80.3	9.3	*	100	99.7	96.6	90.4	86	2630
W42	21.1	80.0	18.6	81.6	95.5	84.5	92	100	87.7	16028
W38	20.85	79.0	12.6	89.4	*	95	*	100	98.1	2055
W13	20.14	76.3	20.4	82.7	87.6	80.7	89.5	91.8	81.6	23596
W28	19.96	75.7	12.2	87.2	90.5	83.9	84.6	85.2	85.8	34194
W43	18.41	69.8	20.2	97.4	*	87.2	54.5	69.9	89.6	7627
8BR	**18.05**	**68.4**	**24.5**	**39.5**	**85.2**	**89.4**	**77.5**	**87**	**76**	**13457**
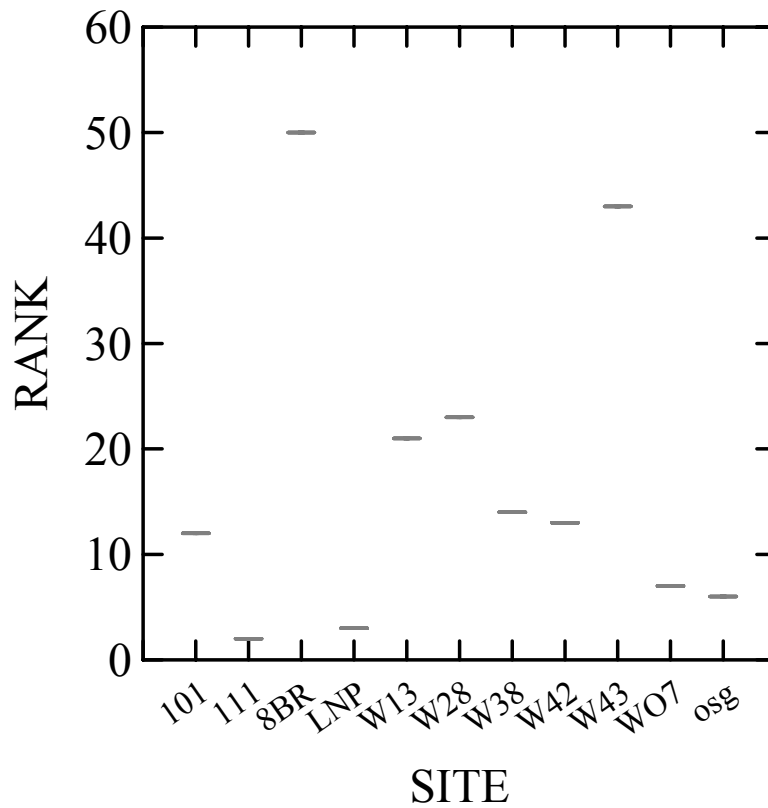
Figure 4.2 Ranking of preagricultural sites within WHHI database (out of 65 sites).

Figure 4.2 shows all preagricultural sites in ranked order (from highest to lowest scores) out of the total 65 sites within the health index. Windover ranked 50th within the index. Nine out of eleven total preagricultural sites within the index ranked within the top 25 percentile of the index, four within the top 10.

Figure 4.3, below, provides the score distributions for each category for all preagricultural sites within the index.
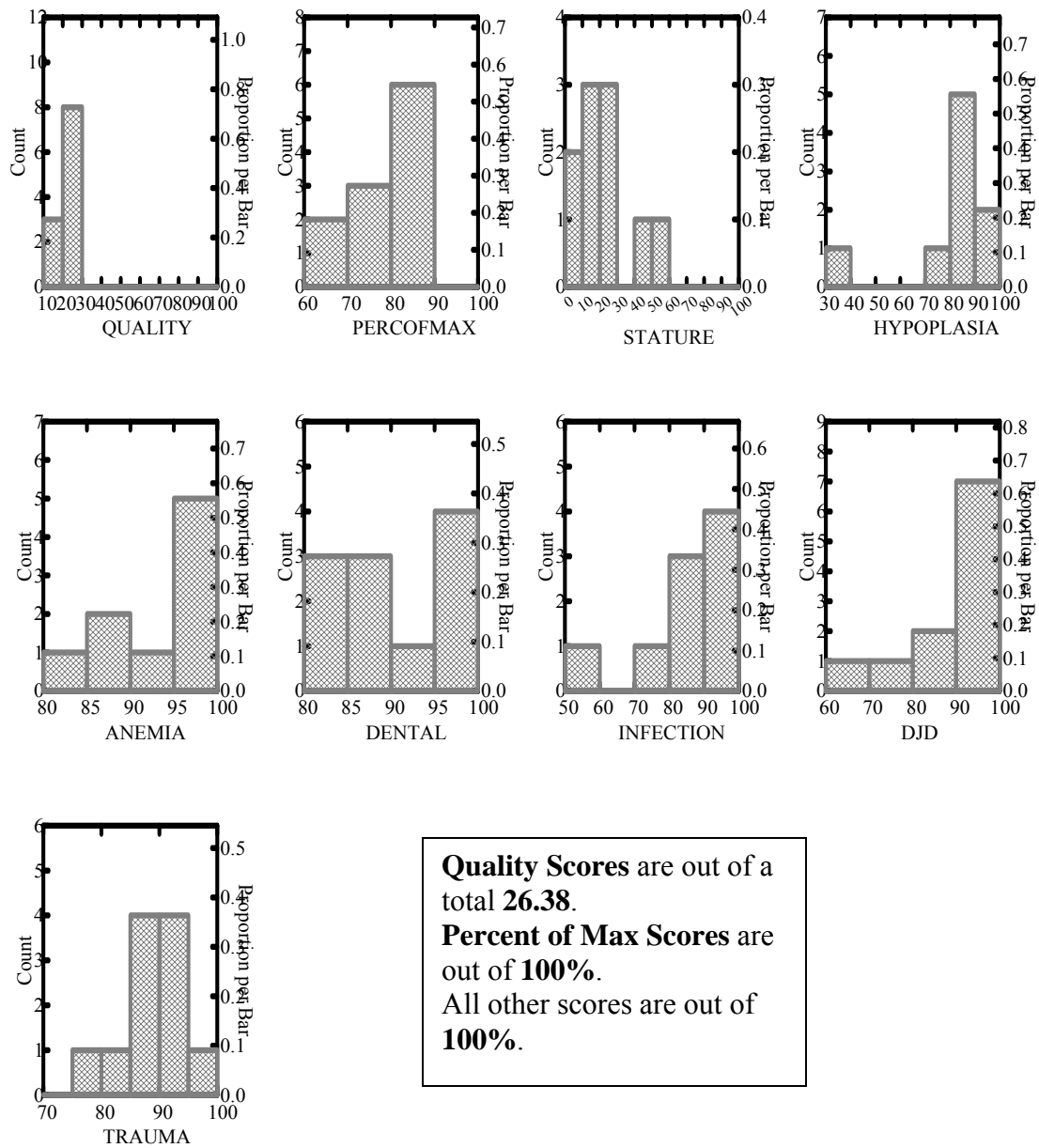
Figure 4.3 Score distributions for all preagricultural groups in the WHHI Dataset (some sites have missing scores for certain categories).

Eight out of the 11 total preagricultural populations within the index scored in the upper half of the quality-of-life scores (maximum score of 26.38 years). Windover scored 18.05 in this category. Half (6) of the preagricultural populations scored in the 80 percentile of the percent of maximum category, whereas Windover scored 68.4 percent.

Only two preagricultural populations scored within the lowest percentile group (60 percent), Windover and W43, a population from Coastal Southern California dating to 1,359 BP.

In general, preagricultural populations scored low in the stature category, with 10 out of 11 scoring in the bottom 50 percentile. However, this appears to be a trend within the dataset, since only two sites out of the total 65 scored above the 50 percentile. The low scores could be artifact from missing data values within the index.

Preagricultural populations did relatively well in the hypoplasia category, with seven out of 11 scoring above 70. Windover was the only population to score outside of this range, with a low hypoplasia score of 39.5. Preagricultural groups also scored high in the anemia and dental categories, with all groups scoring in the top 80 percentile. All but one population (W43) scored within the top 70 percentile in the infection category. Degenerative joint disease scores were very high, with seven out of 11 scoring in the top 90 percentile. Trauma scores were also high, with all preagricultural groups scoring above 75 percent.

In general, all preagicultural groups, with the exception of Windover and W43 obtained high scores within the health index. This data are in keeping with a majority of the literature that supports the premise of better overall health for populations prior to the advent of agriculture and the larger, sedentary social structures that accompanied this shift.

Evaluation of Methodology

To better understand the distribution of scores within the health index, it is important to evaluate the methodology used to evaluate the health of populations within the dataset. This section will analyze the protocols utilized within the index and discuss their strengths and weaknesses.

Interobserver Error

The Western Hemishpere Health Index was designed, in part, to standardize data collection methods within bioarchaeology. The protocol is designed for ease in scoring various pathologic lesions on the skeleton, based on the experience and knowledge of the assessor. Many of the scores are based on presence and absence of pathologic lesions, with some scores taking into account the number of lesions present (for example, enamel hypoplasias). Scoring of skeletal elements is based on the experience and capability of the observer. To evaluate whether the protocol enabled an observer to accurately assess the various skeletal indicators employed within the index, a test of interobserver error was performed.

Three indicators were chosen for the test: cribra orbitalia, enamel hypoplasias, and dental abscesses. Two fellow doctoral students experienced in human skeletal analysis (Michelle Hughes-Markovics and Colette Burbesque) were chosen to score 24 individuals from the research population. Hughes-Markovics and Burbesque were given identical protocols to follow and scored the skeletons based on scoring criteria set forth in the health index. Enamel hypoplasia tests were performed on deciduous and permanent canines and maxillary incisors. Deciduous dentition were later excluded from the tests due to small number of deciduous teeth observed (one) and identical scores.

Table 4.3 Percent agreements for each variable tested.

Coders	Maxillary Incisor Hypoplasias	Canine Hypoplasias	Cribra Orbitalia	Abscesses
1&2	70%	62%	50%	70%
1&3	66%	62%	62%	75%
2&3	70%	50%	41%	70%

Table 4.4 Average percent agreements for each variable tested.

	Maxillary Incisors Hypoplasias	Canine Hypoplasias	Cribra Orbitalia	Abscesses
Average Percent Agreement	68%	58%	51%	71%

Table 4.5 Spearman correlation matrix for enamel hypoplasias affecting maxillary incisors.

	OBS1	OBS2	OBS3
OBS1	1.000		
OBS2	0.920	1.000	
OBS3	0.830	0.866	1.000

Number of observations: 24

Table 4.6 Spearman correlation matrix for enamel hypoplasias affecting permanent canines.

	OBS1	OBS2	OBS3
OBS1	1.000		
OBS2	0.663	1.000	
OBS3	0.471	0.695	1.000

Number of observations: 24

Table 4.7 Spearman correlation matrix for cribra orbitalia.

	OBS1	OBS2	OBS3
OBS1	1.000		
OBS2	0.574	1.000	
OBS3	0.513	0.409	1.000

Number of observations: 24

Table 4.8 Spearman correlation matrix for abscess comparison.

	OBS1	OBS2	OBS3
OBS1	1.000		
OBS2	0.918	1.000	
OBS3	0.821	0.863	1.000

Number of observations: 24

Cribra orbitalia scores had the lowest average percent agreement. When a lesion is present, scores are assigned based on degree of expression. Whether an observer describes a lesion as "gross" or merely present is fairly subjective. This may account for the lower percent agreement in this category. Hypoplasia percent agreements were also low. The scoring criteria for canine teeth allow the observer to score either maxillary or mandibular canines based on which tooth they determine to be most affected. This can result in observers recording scores for different teeth. The scores for incisor defects and number of abscesses were higher, yet neither had impressive agreements. The subjective nature of gauging pathologic defects in human skeletal remains, even utilizing standard criteria, is still problematic. Photo representation of cribra orbitalia standards might improve agreement when gauging the extent of surface involvement. Hypoplastic defects

will continue to be problematic due to the ambiguous physical expression of many defects and the difficulty in obtaining an exact count when using macroscopic technique.

Although several of the skeletal indicators can be problematic, the majority of the scoring criteria are based on presence/absence scoring. Scoring criteria for trauma, although not as inclusive as it could be, is based on presence and absence of fractures, as well as alignment. The criteria for degenerative joint disease also uses language that simplifies the level of involvement assigned to each joint. Most of the dental health categories are also based on presence/absence, as are infection scoring. Overall, the scoring criteria are straightforward and minimize the ambiguity associated with the analysis of pathological conditions in human skeletal remains.

Data Collection Protocol

The data collection protocol utilized within the health index is generally straightforward and provides detailed instructions as to scoring the various skeletal indicators. However, following data collection, it was noted that the fracture assessment protocol is severely limited regarding inclusion of fractures affecting the torso.

In 2003, the author completed a fracture assessment of the Windover population as the subject of her Masters Thesis. This research assessed the type, location and frequency of skeletal fractures within the population in order to make references to their lifestyle. The research provided a foundation for the trauma assessment portion of the current research. It was during this assessment that it was noted that the protocol of the WHHI excludes a number of fractures considered diagnostic in relation to lifestyle, biomechanical load, and interpersonal violence.

Next to the almost ubiquitous degenerative changes seen in archeological specimens, the most common pathological condition affecting the skeleton is trauma (Ortner and Putschar, 1981). This is because trauma frequently involves forces that leave evidence on the skeleton. Trauma, therefore, can provide a broad range of information concerning the physical demands, social structure, and level of conflict experienced in past populations.

Considerable debate has centered on fracture frequency over time. Frantz (1989) examined temporal trends in fracture frequencies and found that individuals from the Woodland period had higher frequencies than those of the Archaic and Mississippian periods. Other studies (Steinbock, 1976) have found the hunter-gatherer lifestyle to be more prone to traumatic injury in some regions of North America compared to more sedentary groups. Studies of skeletal material from the Channel Islands have found high frequencies of depressed cranial fractures over a 7,000-year temporal span of prehistory (Lambert, 1994). Walker (1989) found that the incidence of cranial injuries increased significantly between the early and late prehistoric periods of the Channel Islands and attributed this increase to social and ecological conscription in the area due to increased competition for resources.

Another fundamental aspect of fracture analysis concerns rates of occurrence within populations, which can be indicative of the social structure of a population. Webb (1995) has examined the frequency of cranial fractures in female Australian Aborigines and determined that female crania from all parts of the continent display more head trauma than males. The patterns of trauma exhibited on female crania in this region suggest deliberate attack as opposed to accidental injury, which Webb interprets as injuries resulting from interpersonal violence or self-inflicted wounds sustained during mourning rituals. Either possibility can assist in the reconstruction of social patterns among Australian Aborigines. Powell et al. (1991) found a decreased incidence of skeletal trauma among elite females (as indicated by accompanying grave goods) versus those of non-elite females, which could indicate an absence of physical demands due to their preferred social status. At the Mississippian site of Chucalissa, Tennessee, there was an increase in skeletal fractures among elite males, which has been attributed to their higher social status attained via prowess in warfare.

Saul and Saul (1997) attributed a higher incidence of fractures in males from the Preclassic Mayan site of Cuello to combat or sports. Lovejoy and Heiple (1981) examined fracture prevalence in the late prehistoric Libben series from Ohio and found that fracture rates within this population peaked in two age groups: adolescence/young adulthood (15-25 years) and old adulthood (45+ years). They attributed these fracture

frequencies to accidents due to the fact that they were equal between the sexes and did not exhibit injury patterns associated with assault.

Walker's (1989) studies from the Channel Islands found that depressed fractures were rare in individuals under the age of ten, while they were especially common between adolescence and 40 years of age. Fractures were found primarily in males, with two-thirds of the injuries occurring on the left side of the frontal bone, indicating face-to-face encounters with a right-handed perpetrator (Lambert, 1994). Larsen (1997) cites numerous accounts of interpersonal conflict among Native American populations, as seen in their skeletal remains. Indications of aggressive behavior are reflected in patterns and types of fractures, such as parry fractures of the forearm and scalping wounds on the crania.

In Webb's (1995) examination of cranial trauma in Australian Aborigines, he found that almost all the depressed fractures were between one and three centimeters in diameter, round or oval and typical of that made by a blow from a blunt instrument with a small but symmetrical striking surface. Scuilli and Gramly (1989) found evidence of violent death among the Colonial period remains excavated from Ft. Laurens, Ohio in the form of cut and hack marks, particularly of the cranium. Blakely and Mathews (1990) attributed evidence of violence among Native Americans of Georgia to conflict with de Soto's army, possibly in the form of rebellion to enslavement or attempts to free others from enslavement. The skeletal evidence revealed deep gashes and cuts to extremities, most likely inflicted by steel weapons, although these findings have been disputed in later works (Milner et al., 2000).

The similar size and shape of many of the Santa Barbara Channel cranial injuries suggest that they were produced by some well defined, culturally regulated pattern of violence, perhaps involving a specialized weapon (Walker, 1989:319). These injuries were confined almost entirely to the frontal and parietal bones and were more common on the left side than the right. This may indicate face-to-face confrontations. Zimmerman et al. (1981) mention the common "70 caliber" depressed fractures of sling ball wounds that produced frequent cranial injuries among ancient Peruvians. Among the Oneota, a pre-contact aboriginal population from west-central Illinois dating to ca. AD 1300, 43 of the 264 burials excavated belong to individuals who died violently (Milner et

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al., 1991). Massive cranial injuries with fracture patterns consistent with the blunt force produced by ground-stone celts were common among individuals displaying trauma. The authors attribute these violent injuries to small-scale society warfare due to the high level of traumatic death exhibited in male skeletal remains.

In contrast, Lovejoy and Heiple (1981) attributed traumatic injuries from the Libben Site in Ohio, a Late Woodland sample, primarily to accidental injury. By examining the general etiology of fractures from this population, they found that fractures generally occurred during adolescence and young adulthood; fracture frequencies were equal among males and females with the exception of the oldest age groups; most fractures were typical of accidental mode, such as Colle's fractures; there was no indications of battered individuals; and the fracture risk for the population was generally low.

Because of the amount of information provided by trauma analysis, data collection protocols should be as inclusive as possible. The protocols for trauma assessment within the WHHI involve only fractures of the head, face and limbs. Fractures of the torso are excluded. Table 4.9 provides a numeric breakdown of the number of torso fractures from individuals within the current analysis that were excluded based on data collection criteria of the health index.

Table 4.9 Type and number of fractures missed by the WHHI protocol.

Rib Fractures	21
Vertebral Fractures	10
Total Torso Fractures excluded (clavicle, rib, vertebral, ischiopubic, scapula)	37

The exclusion of these fractures prevents several types of analyses. Compression fractures of the vertebrae can be indicative of mechanical stress associated with high physical demands, as well as traumatic injury (Zivanovic, 1982). Variation in frequency of such fractures between males and females can be indicative of division of labor as well

as differences in social roles. This information can provide insight into a group's social structure. Rib fractures can also be telling. Caused from blunt force trauma, they can be the result of accidental injury. However, when observed in conjunction with other traumatic injuries, they can indicate interpersonal violence (Byers, 2002). This is another area where the health index protocol falls short.

There is no means of recording multiple injuries on an individual. Since multi-trauma events are highly indicative of interpersonal violence, there is no way to gauge the presence or level of intentional injury within a population using the current protocol. Although previous research (Smith, 2003) found little evidence of interpersonal violence among the people from Windover, this information could be applicable and useful when assessing other archaeological populations.

Because of the exclusion of torso fractures from the index, several other elements are left out of the study, such as fractures of the clavicle, sternum, pelvis and scapula. These types of fractures, in isolation or in combination, can provide information as to the type and frequency of traumatic injuries experienced within a population.

Data Computation

Another problematic factor of the health index was rectified during the course of the project. When this project began, there was no established online access to the database that allowed individual researchers to enter data and compute health index scores. The author contacted Anna Kjellstrom, a doctoral candidate at the Osteoarchaeological Research Laboratory at Stockholm University, Sweden, who ran the data and provided scores for the Windover population. Kjellstrom had access to the database through her husband's participation in the project, designing the program that computed the health index scores. The program became available online toward the end of this project. It is now available at the Global History of Health Project (http://global.sbs.ohio-state.edu/project_overview.htm).

Although the program is now available online, there were several instances where new data were inputted yet the scores either remained the same or changed in other fields not associated with data corrections.

Following the initial score calculation, the author noted that stature calculations for adults within the Windover population where approximately 9 cm shorter than stature estimations made by Dickel and Doran. It was noted that a correction factor (Scuilli et al., 1990) had not been used at the time the author calculated stature. Corrections were made and the data were re-run by Kjellstrom. Upon completion of the second round of score calculation, however, the stature scores remained the same, even though multiple scores had been adjusted up by approximately 10 cm, yet other scores within the index were different (infection). Table 4.10 shows the scores before and after stature adjustments.

Table 4.10 Total scores for the Windover population before and after stature adjustments were made.

QALY	% of max.	Stature	Hyp.	Anemia	Dental	Inf.	DJD	Trauma	Pers. yrs.
18.02	68.3	24.5	39.5	85.2	89.4	76.7	87.0	76.0	13457

QALY	% of max.	Stature	Hyp.	Anemia	Dental	Inf.	DJD	Trauma	Pers. yrs.
18.05	68.4	24.5	39.5	85.2	89.4	77.5	87.0	76.0	13457

The author consulted with Kjellstrom, who explained that although the statures were adjusted the changes were not enough to affect the overall stature scores. However, when the population was divided by sex and the scores calculated with the new statures, there were multiple changes in various categories (quality, stature, hypoplasias, anemia, infection, DJD, trauma and person years), although no data had been changed aside from stature. Table 4.11 shows the scores before and after the changes in stature were admitted.

Table 4.11 Scores calculated for males and females from Windover before and after stature adjustments.

Sex	QALY	% of max.	Stature	Hyp.	Anemia	Dental	Inf.	DJD	Trauma	Person-yrs.
Male	17.56	66.6	24.5	38.7	86.3	89.3	65.0	86.8	75.2	11489.
Fem	17.24	65.4	23.5	40.0	76.3	87.0	66.5	90.3	73.8	4716.

Sex	QALY	% of max.	Stature	Hyp.	Anemia	Dental	Inf.	DJD	Trauma	Person-yrs.
Male	18.16	66.8	26.1	37.3	94.3	89.8	82.7	85.5	69.7	6675
Fem	17.24	65.4	23.5	40.0	76.3	87.0	66.5	90.3	73.8	4716.

There was no explanation why the other categories where changed by the re-calculation. It appears to be a factor inherent to the computer program. At a later date, trauma scores for arm, leg and face required adjustments, since scores of zero were assigned to elements that were present yet lacking traumatic injury. These elements should have been assigned a score of one. Although the adjustments did not affect the number of fractures, a significant number of scores that were initially zero were changed to one. By this time, the computer program to calculate health scores was available on-line and the author was able to enter the new data and calculate scores. The overall trauma and health scores were unchanged by the adjustments in scores, yet several other categories had minor shifts in numbers. To evaluate whether there were still fluctuations in scores following the availability of the online data program, data in certain categories were altered and scores were computed by the author. The only scores affected following the tests were those directly related to the data changes and overall scores. It appears the fluctuations in scores were part of the transitional period in program development and have since been corrected.

The nature of the computer program used to calculate scores for the Western Hemisphere Health Index, although user friendly and accessible is problematic due to the "black box" nature of the software. Because scores are entered into the program and calculated blindly, it presents questions as to the reliability of the program, especially when scores change in the absence of new data. Another difficulty with the index is that

individuals in the database of raw scores available online are not assigned to the sites published in the book. The 65 published sites are combinations of sites based on ecological and chronological similarity. Therefore, examining raw numbers is impossible, since the ultimate site designation of many individuals within the online dataset is unknown. It would have been useful to have the number of individuals assigned to each site included in the published text.

Overall, the methodology of the index is user friendly and clearly defined. There may always be issues of interobserver error due to the subjective nature of lesion description and trauma scores would be more revealing if the categories were expanded to include torso fractures. The "black box" nature of the computer program will always be problematic but future goals of the index include determination of functional consequences of these skeletal indicators and whether equal weight should be applied to each.

Windover Health

The final issue to be examined in this chapter is the possibility that the Windover population is idiosyncratic in regards to their overall health, falling outside the norm for preagricultural populations. Considering the scores obtained by Windover compared to other hunter-gatherer populations within the dataset, perhaps the low scores were the result of environmental, dietary, or social issues exclusive to this population. Each of these factors will be examined.

Environmental

During the period that the people from Windover were utilizing the pond for the interment of their dead, climatic and sea level fluctuations characteristic of the early Holocene were tapering off, eventually producing complex estuary systems (9,000-6,000/5,000 years B.P.), which would become dominant resource procurement areas for many southern Florida populations (Dickel and Doran, 2002). Pollen profiles indicate a dry, oak woodland over much of the peninsula, interspersed with wetlands, including

freshwater marshes, hardwood and cypress swamps, and bayheads (Tuross, et al., 1994). The subtropical climate combined with numerous water sources would have provided environmental conditions conducive to the support and transmission of diseases caused by invertebrates such as leeches, worms, mites, and spiders (Ewel, 1990). Among the dipterans (a family of flies in the order Diptera) found in cypress ponds are at least eighteen species of mosquitoes (Davis, 1984).

Parasites would also have been present. Spread to humans via ingestion, contact with soil infected with fecal matter, consumption of meat containing larvae, and mosquito bites, parasites would have had a negative impact on health at Windover. Reinhard (1990) discussed paleoparasites recovered from coprolites from a burial site on Daws Island off the coast of South Carolina. Nematode adults were observed in fecal smears taken from intestinal contents of one burial, which were morphologically consistent with hookworms. Included in the study are sites from across North America where parasites have been recovered from coprolitic remains.

Hookworm infestation remains endemic to the tropics and subtropics and outranked all other parasitic diseases for morbidity a generation ago, with the World Health Organization estimating about 25 percent of the world's population affected (Talaro and Talaro, 1993). Once the worms reach the small intestine, they anchor and engorge with blood before reaching the adult stage. Heavy worm burdens can produce iron-deficiency anemia secondary to significant blood loss, making infants especially susceptible to hemorrhagic shock.

Climate would have also played a role in the transmission of pathogens among the people of Windover. Warm weather provides suitable environments for the reproduction of insects, many of which are harmful to humans. The wet season characteristic of Florida's long summer would have also had negative health implications. Disease vectors, like mosquitoes and flies are more abundant during the wet season and many intestinal parasites are transmitted by means of contaminated water or soil, with exposure to these more likely during the wet season (Sattenspiel, 2000). The wet season would have meant more time inside, which would also have aided the spread of respiratory infections. Respiratory transmission of disease occurs when infectious droplets are spread through coughing, sneezing, or direct contact. In addition to colds, influenza, and

pneumonia, many of the familiar childhood diseases, such as measles, mumps, and influenza, are spread by this means (Sattenspiel, 2000:14). The high temperature, humidity, and rainfall characteristic of Florida would have enabled many disease vectors to reproduce during much of the year, leaving the inhabitants of Windover susceptible to a number of infectious organisms.

Oxenham et al. (2005) traced the skeletal evidence for the emergence of infectious disease in populations from Bronze and Iron Age populations in Northern Vietnam. They identified potential factors contributing to the emergence of infectious disease in the region during the Metal period, which included increased contact with bacterial or fungal pathogens either directly or by way of vertebrate and/or arthropod vectors and the evolution of pathogens present in Mid-Holocene human hosts into more virulent forms in the Metal period. Moffat (2003), in a study of growth velocities of children in Kathmandu, Nepal, found that growth retardation was present among children suffering from diarrhea and respiratory infections but was even more pronounced in children affected by protozoan gastrointestinal parasites. Blom et al. (2005:152) found that environmental stressors, such as parasites and disease, rather than specific dietary practices were found to be more likely associated with childhood anemia in coastal Andean skeletal samples.

Rampant parasitism likely caused iron-deficiency anemia and occasional cases of megaloblastic anemia among high-status individuals from the Medieval Gilbertine Priory of St. Andrew, York, England (Sullivan, 2005). In a study of modern-day children in rural Guinea, Africa, Glickman et al. (1999) attributed a high incidence (53 percent of children tested were infected) of soil-transmitted nematodes to the practice of geophagia, the ingestion of dirt. The people of rural Guinea share a belief in the magical and spiritual properties of the earth and a genuine enjoyment for the habit of ingesting dirt. Dental attrition among the people of Windover is pervasive, indicating a high level of grit in the diet. Whether intentional or not, perhaps the ingestion of dirt attributed to dental attrition and may have promoted infestation from parasites within the group.

Inadequate means of human waste disposal would have played a role in the transmission of infectious organisms at Windover. Archaeobotanical evidence, from plants associated with burials and wooden stakes possibly used as grave markers or

anchoring points, indicates the people of Windover were utilizing the pond during the latter summer/early fall months (Tuross et al., 1994). During this time, the area would have provided the necessary resources of food and water but would also have served as a place for the disposal of waste. Human fecal matter, discarded food remains, and rotting fruit and meat would have provided ample means for the transmission of infectious organisms. The tropical pattern of rainfall seen in Florida, with its frequent heavy cloudbursts, exacerbates the problem of inadequate sanitation systems, because it can result in high volumes of sewage-laden water flowing near dwellings and playing children (Sattenspiel 2000). Soil contamination from waste would have put individuals in close contact with pathogens. Contaminated water would also have contributed to pathogen loads. The environments associated with hunter/gatherer people, whether warm or cold, would have posed considerable challenges to those so dependent on the natural world around them.

Dietary

Stable isotope analyses and archaeobotanical reconstruction have provided much information as to the types of foods utilized at Windover. Tuross et al. (1994) have reported on stable isotopes recovered from human bone collagen, signatures that are consistent with a diet dominated by animal protein at the "second" trophic level such as duck, turtle, and catfish. Botanical data from their studies identified 31 potential food or medicinal plants recovered in association with burials. Seeds of edible, fleshy fruits such as hackberry, persimmon, red mulberry, prickly pear and wild plum dominated the plant assemblage. The overall human dietary pattern at Windover suggests a complicated and widespread use of seasonally available plants and riverine animals that could be nutritionally adequate in providing calories, protein, fats, carbohydrates, minerals, and variety (Tuross et al., 1994:300).

The skeletal remains, however, indicate that although the people of Windover utilized a variety of foods, nutritional stress affected a large number of individuals, as evidenced by the presence of cribra orbitalia, porotic hyperostosis, enamel hypoplasias and signs of infection within the population.

The presence of pathologic conditions indicative of biological stress, such as enamel hypoplasias affect mortality rates. Duray (1996) found that individuals with enamel defects followed separate age-at-death distribution curves compared to those lacking defects among members of the Libben population from Ohio. Those with defects strayed from the normal curve, exhibiting two peaks, the first in the 15-20 year age class; the second in the 30-35 year age class. Duray attributes these early mortality patterns to biological damage to the immune system during prenatal or postnatal development.

Brickley and Ives (2006) attributed orbital lesions typically associated with iron deficiency anemia to probably scurvy among infant remains from the historic cemetery at St. Martin's in England. Malnutrition can propel the individual into a negative feedback loop of poor health. Malnutrition can increase susceptibility to disease and cause increases in the severity of the infectious process (Sattenspiel, 2000). Illness itself can lead to malnourishment. Individuals who are ill are also typically malnourished because of loss of appetite or inability to take in or utilize nutrients (Jerome et al., 1980). This can lead to chronic conditions. Nutrition is an important and intensively investigated determinant of immune function (McDade, 2003).

Seasonal use of sites can also result in seasonal shortages of food, should environmental factors, such as drought or flooding, affect availability. Seasonal variations common in primitive communities, with regard to both quantity and quality of food, may have some deleterious effects on growth and health, especially among children (Dubos, 1965).

Biological stress can prolong the infectious process, increasing recovery time. A potential source of infectious disease in early hunter-gatherers was their close contact with the animals they hunted and their ingestion of meat, possibly infected, from these animals (Merbs, 1992). A number of infectious organisms can be transmitted via animals, such as anthrax, toxoplasmosis, taeniasis (tape worms) and possibly tuberculosis and influenza.

The diet of hunter-gatherers is precarious, highly dependent upon environmental and seasonal stability. Shifts in resource availability could impact the entire population, one individual at a time. Resource variability would require social response to solve issues of shortage. The role of society, as it pertains to group health, is our next topic.

Social Structure

How one lives has as much of an impact on overall health as where one lives and what they eat. The social structure of a population determines the means of subsistence, access to resources, and population density – all of which have direct bearing on the level of health within the group.

The Early Archaic in Florida precedes cultural developments leading to pottery production and to the apparently more widespread sedentism of later periods (Newsom, 2002:191). However, the Windover site was utilized for perhaps as long as 1,000 years (Tuross et al., 1994). Seasonal use of the site in conjunction with the size of the cemetery indicates that the inhabitants of Windover may have practiced a more sedentary existence than that typically associated with hunter-gatherers. Archaeobotanical evidence establishes seasonality of the site as late summer/early fall (Newsom, 2002), indicating the inhabitants were sedentary for at least part of the year. Thus, the Windover site may represent the incipient stages of sedentism among Florida's early inhabitants.

We know that the shift from hunter-gatherer subsistence to that of agriculture led to declines in oral and general health (Larsen, 1995). This shift led to reductions in health status, increases in physiological stress, declines in nutrition, and changes in work loads. But many of these changes were not solely the result of changes in diet. They were the result of the associated changes in the social structure of the group itself. Populations increased, bringing people into tighter living quarters, increasing the spread of opportunistic infection. Sanitation issues became more problematic. Pathogen loads became more diverse. Food procurement became more challenging as populations grew. Environmental changes, such as drought, became more detrimental as groups lost the ability to move to better areas. These changes had subsequent impact on health and disease. Even the earliest stages of sedentism, such as the seasonal occupation of sites, would incorporate many of these same issues. The result would be a decline in health as groups physiologically adjusted to such changes.

Declining health is well established as a consequence of changes in subsistence and social structure. Even when subsistence shifts are made from one stable form to another, there can be associated deterioration in health. Lambert (1993) documented the

changes in health among prehistoric populations of the Santa Barbara Channel Islands. She noted increases in inflammatory bone lesions, increased rates of enamel defects and reduced stature among populations as they shifted from a generalized maritime hunting and gathering subsistence to one focused increasingly on fishing. Although fish provide adequate levels of protein, over time, population increased, trade and exchange increased, which increased rates of contact between islanders and mainlanders. Infectious disease increased, as indicated by a rise in the instances of periosteal reaction over time.

Kent and Dunn (1996) tracked increases in anemia and decreases in overall health among hunter-gatherers of the Kalahari Desert. They found high morbidity rates, in spite of adequate diet, which they attributed to the transition from a nomadic to a sedentary and dispersed to aggregated settlement pattern.

Aggregated settlements led to increases in the transmission of pathogens. Many diseases are transmitted via infectious droplets spread via breathing or coughing. This happens much more easily when large numbers of humans live in close association with one another on a regular basis; hence, droplet transmission increased significantly after humans settled down and began living in larger, more sedentary communities (Sattenspiel, 2000:14).

Windover would have experienced changes in health associated with the early stages of sedentism. Because we have not discovered associated living sites, we must rely on inferences made from archaeologically recovered materials. What we do know is that the pond served as a focal point for the interment of the dead; one that was revisited over generations.

The excavation of the remainder of the pond would prove enlightening. Approximately half the pond was excavated during three field seasons, the remainder of the pond left intact. How many individuals remain in the pond is unclear but if the excavated areas reflect a homogeneous distribution throughout the pond, there could be a significant number of people remaining. Whether the remaining individuals exhibit similar rates of pathology remains unknown. What we do know is that when compared to other archaeological populations, levels of health at Windover attest to the physical challenges and hardships of the Archaic.

CHAPTER 5 - CONCLUSION

The purpose of this research was to utilize the Western Hemisphere Health Index to gauge the level of health of an Archaic population, to compare their level of health to other populations already assessed using this methodology, and to critique the methodology itself. It was assumed the Windover population would obtain high scores using the index. They were a population predating agriculture, thereby avoiding the health costs associated with agricultural subsistence.

The Windover population was evaluated according to the WHHI. Scores were compared to the rest of the dataset, in which they ranked 50th out of a total of 65 sites. They also ranked lowest out of all preagriculture groups within the index. Windover scored above the means/medians for all groups in stature, dental health, and degenerative joint disease yet scored below the means/medians in quality of life years lived, percent of maximum, hypoplasias, anemia, and trauma scores. They scored between the mean and median in infection.

When the population was divided by sex, males outscored females in quality of life years lived, percent of maximum, stature, anemia, dental health, and infection. They also had a higher number of life years lived, yet this could be due to a higher number of individuals in their category (35 females, 43 males). Females outscored males in hypoplasias, degenerative joint disease and trauma. The differentiation in health does not appear to be related to diet or access to resources, since stable isotope analyses indicate similarities in types of plants utilized and levels of protein. Analysis of oxygen isotopes indicates there were no "outliers" and that the entire group utilized the same water sources throughout life. If the group did fragment during the year, it appears they remained within close approximation of each other, according to oxygen isotope signatures. This also indicates that the group remained together throughout the year instead of dispersing to separate territories.

The resultant low scores obtained by the Windover population were evaluated in Chapter 4. To assess how other preagricultural populations scored within the index, these sites were isolated and their scores compared. Nine out of eleven total preagricultural populations scored within the top 25 percentile of the index; four of these in the top ten.

Next, the methodology of the index was assessed to identify weaknesses. Interobserver tests of three of the scoring criteria (cribra orbitalia, enamel hypoplasias, and dental abscesses) were conducted. Results indicate that of these criteria, interobserver error can be substantial, as indicated by percent agreement tests (51 percent agreement for enamel hypoplasias; 58 percent and 68 percent agreement for canine and incisor hypoplasias, respectively; and 71 percent agreement for cribra orbitalia). However, the majority of scoring criteria are based on presence/absence of pathological conditions, thereby minimizing interobserver error among most of the scores.

Scoring criteria for fracture assessment was found to be severely limiting. Fractures of the torso are excluded by the criteria, which includes only longbones, facial, and cranial trauma. Vertebral and rib fractures, which can be indicative of biomechanical load and interpersonal trauma, are not recorded, thereby limiting the range of inferences that can be made via trauma assessment. Also excluded from the criteria is a means to record multiple fractures. A total of 37 fractures were excluded from scoring due to restrictions in criteria.

Computation of data was also problematic. Data were inputted into a program that calculates final scores within each category. The program designers understand the mechanics of the program, yet the typical user is given no insight into how the scores are actually calculated. This "black box" aspect of the methodology is unsettling for users. The scores themselves can be a bit erratic. When adjustments were made to select categories of data, final scores within these categories were not affected yet other scores fluctuated. There was no explanation for the change in scores. At the start of this project, the actual program was not available online. This situation has now been resolved and users can input their own data using the WHHI website. Publication of the online data program also appears to have solved the problem of fluctuating scores, since tests performed indicated no aberrant fluctuations in data.

Factors that may have contributed to the low health scores at Windover were evaluated, including environmental conditions, diet, and social structure. The warm subtropical climate of Florida's Archaic would have provided a setting conducive to infectious agents such as mosquitoes, parasites, and infectious agents. Diet at Windover, primarily riverine, would have provided ample nutrition for the most part. Yet there must have been periods of scarcity, as indicated by the presence of cribra orbitalia, enamel hypoplasias, and porotic hyperostosis – all signs of biological stress. The social structure of the Windover populations was most intriguing. It is suggested here that the people of Windover were transitioning from typical hunter-gatherer existence to a more sedentary arrangement. The seasonality of the site was established by archaeobotanical evidence and radiocarbon dating indicates the site was utilized for possibly up to 1,000 years. Adjustment to a more sedentary existence would mean larger numbers of individuals living in closer proximity for longer periods of time. This would result in greater diversity of pathogens, increased exposure to infectious agents, and sanitation issues associated with large groups. Perhaps the low scores obtained by the Windover population are a reflection of the physiological changes necessary for a group to adjust to a new social climate.

The methodology of the Western Hemisphere Health Index provides a standard protocol for the assessment of human skeletal remains. The majority of the scoring criteria are based on presence/absence, the instructions are clear and easy to follow, and the use of multiple skeletal indicators provides a comprehensive evaluation of health. The populations within the dataset are from broad temporal and geographic ranges and include an impressive number of individuals for comparison. Online availability and expansion of the index to other areas of the world will prove a significant achievement to the field of bioarchaeology.

The application of the Western Hemisphere Health Index proved a valuable lesson in the complexity of bioarchaeological analysis. Although the Windover population does not appear to have been as healthy as other preagricultural populations, it prompted an evaluation of the complexity of health issues encountered by such groups. The environment, diet, and social structure of these people would have posed considerable challenges to those carving out an existence during Florida's Archaic.

APPENDIX A – STABLE ISOTOPE ANALYSIS

Twenty individuals from the Windover site were assayed for $\delta^{13}C$ and $\delta^{18}O$ ratios from the mineral (hydroxyapatite) portion of bone. The organic (collagen) portion of bone was not assayed due to complexities with regard to Rhoplex preservative. Results show no significant differences in diet or area of residence between males and females based on $\delta^{13}C$ and $\delta^{18}O$ values. However, three females and one male cluster apart from the other 16 individuals based on their $\delta^{13}C$ values. The differences in diet may be culturally induced or may represent changes in dietary patterns over the long (ca 1,000 year) use of the site.

Background

The use of light stable isotopes in bioarchaeology is now routine. The light stable isotopes commonly employed in bioarchaeological research to reconstruct diet and migration include carbon, nitrogen, and oxygen. Carbon and oxygen are present in bone apatite and were generated for this research.

Carbon isotopes in terrestrial systems vary by photosynthetic pathway. There are three photosynthetic pathways C_3, C_4, and CAM. C_3 plants have $\delta^{13}C$ ratios from -35 to $-20‰$ with an average of $-26.5‰$ (Smith, 1972; Smith and Epstein, 1971). C_4 plants have $\delta^{13}C$ values that range from -15 to $-7‰$ with a mean of $-12.5‰$ (Smith, 1972; Smith and Epstein, 1971). Edible CAM plants, largely limited to succulents in arid areas with low summer rainfall, have $\delta^{13}C$ values that overlap with C_3 and C_4 plants. Generally, CAM plants are not a substantial concern in the Eastern Woodlands, though prickly pear (a CAM plant) does grow along the eastern coast and has been identified at Archaic sites including Windover (Doran, 2002; Newsom, 1994; Tuross et al,. 1994). Carbon isotopes also differ between terrestrial and marine systems. Marine vertebrates typically have $\delta^{13}C$ values of -19 to $-9‰$ compared to the -35 to $-20‰$ range of C_3

plants (Schoeninger and DeNiro, 1984; Smith, 1972). Therefore, in systems where C_4 or CAM input is negligible, carbon values alone can differentiate between a terrestrial and marine diet.

Oxygen isotopes track temperature, precipitation, and evapotransportation. The $\delta^{18}O$ of precipitation is largely determined by the ambient temperature and the amount of precipitation. Generally, warmer weather results in enriched $\delta^{18}O$ values and cooler weather in decreased $\delta^{18}O$ values (Bryant et al., 1996). Temperate regions, which tend to have more constant rainfall and varied temperatures show enriched $\delta^{18}O$ values during the summer months (Gonfiantini, 1985). In tropical regions, which experience more consistent temperatures, $\delta^{18}O$ values track the amount of rainfall (Njitchoua et al., 1999). Broadly similar regions have similar seasonal $\delta^{18}O$ averages, these averages differ in a predictable fashion by latitude, altitude, and distance from the sea. As a result $\delta^{18}O$ values are successfully employed in studies of migration and immigration in archaeological contexts.

Bone is primarily composed of two components, collagen and hydroxyapatite. Both fractions have been used in isotopic analysis and each provides different information about diet. Carbon isotopes from protein are preferentially routed to the collagen in bone, up to 70 percent of the carbon in bone collagen is from the protein portion of the diet. However, the $\delta^{13}C$ in bone apatite records an average of the entire diet because it derives in equal proportion from carbohydrates, lipids, and proteins.

Previous isotopic research on remains from the site demonstrated that the preservative applied to the remains, Rhoplex, is difficult to remove and would be expected to skew $\delta^{13}C$ values derived from bone collagen (see Tuross et al., 1994). Fortunately, Rhoplex is an organic molecule and should not interfere with $\delta^{13}C$ values derived from the inorganic bone apatite fraction of bone. Nevertheless, Toluene was used to remove the Rhoplex from each bone sample, in anticipation of analyzing the organic fraction. As it stands, however, due to the complexities of the Rhoplex on the organic fraction of bone from Windover, that research is not being pursued at this time. The Rhoplex and Toluene treatment should not present a problem to the isotopic data from bone apatite, as indicated by tests conducted on bone samples.

Bone apatite samples were mechanically cleaned and crushed into a fine powder. To remove the Rhoplex from these samples, bone powder was loaded into an Accelerated Solvent Extractor (ASE) which injected 99.9 percent toluene into the samples at 1,500 PSI and 100°C. The solvent combined with the pressure and heat ideally would remove the Rhoplex from each sample. After treatment the solvent was allowed to dissipate from the sample. After ASE treatment, each sample was placed in a 15ml centrifuge tube and treated with ~12 ml 2.5 percent sodium hypochlorite solution for 16-24 hours until all organics were removed. Next, ~12 ml of 0.2 m acetic acid was added for ca. 16 hours. Finally, each sample was rinsed and freeze dried.

Results

There appears no significant difference in $\delta^{18}O$ values between the sexes at Windover, the average $\delta^{18}O$ value for Windover males (N=10) was -1.1‰ and -1.1‰ for Windover females. The average $\delta^{13}C$ value for Windover males was -11.7‰ and -11.5‰ for Windover females. There is no significant difference between the diets of males and females at Windover. However, one male and three females had $\delta^{13}C$ values that diverged from the rest, females number 83, 61, and 74, as well as, male number 64 all had $\delta^{13}C$ values greater than -10.2.

Due to fractionation, the values of the tissues do not directly reflect the $\delta^{13}C$ values of the food consumed. The average isotopic value of the diet is calculated by subtracting -9.5‰ from the $\delta^{13}C$ ratio of the apatite (Ambrose and Norr, 1993). Thus the average male diet at the site was -21.2‰ and the average female diet -21.0‰ providing a combined $\delta^{13}C$ average of 21.1‰.

Tuross et al. (1994) reported an average $\delta^{13}C$ from collagen of 15.5‰ for a small sample (n=6) of individuals from the site. They also report an average $\delta^{15}N$ from bone collagen of 11.8‰. Based on these values, they suggest a mixed diet consisting mainly of terrestrial and riverine resources with limited amounts of estuarine foods.

The $\delta^{13}C$ values from the apatite support Tuross et al.'s (1994) findings. Based on the -21.1‰ average, the people at Windover consumed few, if any, marine resources.

The lower collagen value suggests small amounts of marine protein may have been consumed.

Combined, the four outliers have an average $\delta^{13}C$ of -9.5‰, over 2‰ higher than the site average. These higher values may suggest a higher intake of marine resources. It is also possible these individuals ate more C_4 or CAM resources than the rest of the population, or that they fed on browsers that consumed more of these resources.

The $\delta^{18}O$ and $\delta^{13}C$ data from bone apatite at the Windover site do not show any differences between males and females. The sample contains no "extralocal" individuals based on $\delta^{18}O$ values, nor does there appear to be any difference in bulk diet between the sexes. There are dietary differences between the majority of the individuals and a few outliers, but whether these differences are culturally or temporally induced remains unclear.

Windover males and females

Oneway Analysis of d18O By Species

109
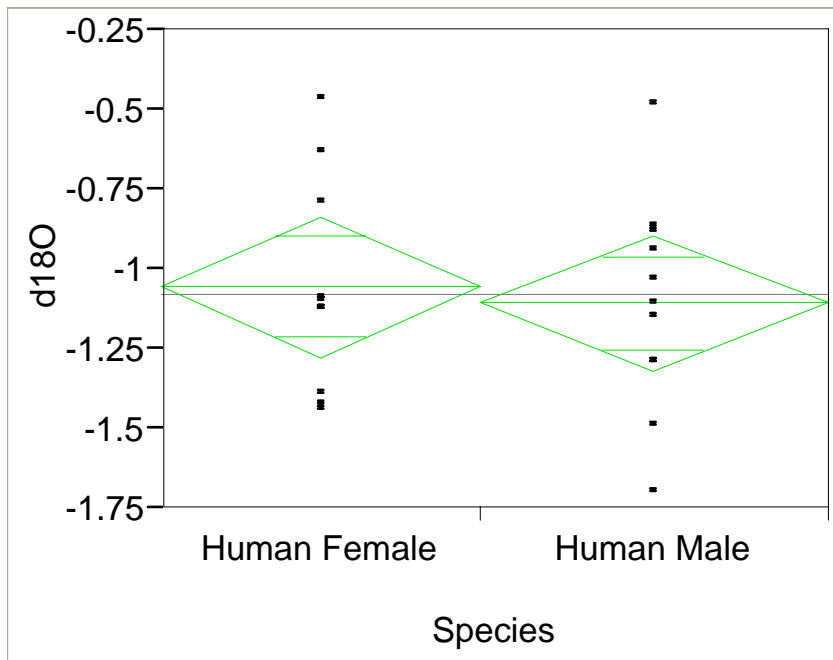
Oneway Anova

Summary of Fit

Rsquare	0.006835
Adj Rsquare	-0.04544
Root Mean Square Error	0.333825
Mean of Response	-1.08308
Observations (or Sum Wgts)	21

t-Test

	Difference	t-Test	DF	Prob > |t|
Estimate	0.05274	0.362	19	0.7216
Std Error	0.14586			
Lower 95%	-0.25254			
Upper 95%	0.35803			

Assuming equal variances

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Species	1	0.0145716	0.014572	0.1308	0.7216
Error	19	2.1173436	0.111439		
C. Total	20	2.1319152			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
Human Female	10	-1.0555	0.10556	-1.276	-0.8345
Human Male	11	-1.1082	0.10065	-1.319	-0.8975

Std Error uses a pooled estimate of error variance

Windover Males and Females

Oneway Analysis of d13C By Species
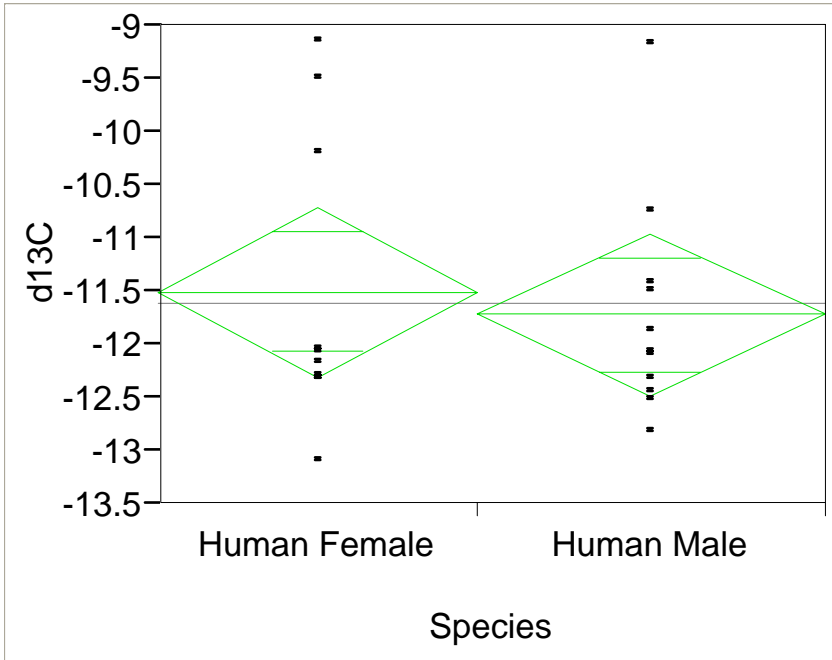
Oneway Anova

Summary of Fit

Rsquare	0.008121
Adj Rsquare	-0.04408
Root Mean Square Error	1.200972
Mean of Response	-11.619
Observations (or Sum Wgts)	21

t-Test

	Difference	t-Test	DF	Prob > |t|
Estimate	0.2070	0.394	19	0.6977
Std Error	0.5247			
Lower 95%	-0.8913			
Upper 95%	1.3053			

Assuming equal variances

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Species	1	0.224366	0.22437	0.1556	0.6977
Error	19	27.404354	1.44233		
C. Total	20	27.628720			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
Human Female	10	-11.511	0.37978	-12.31	-10.72
Human Male	11	-11.718	0.36211	-12.48	-10.96

Std Error uses a pooled estimate of error variance

Species=Human Female

Distributions

d18O
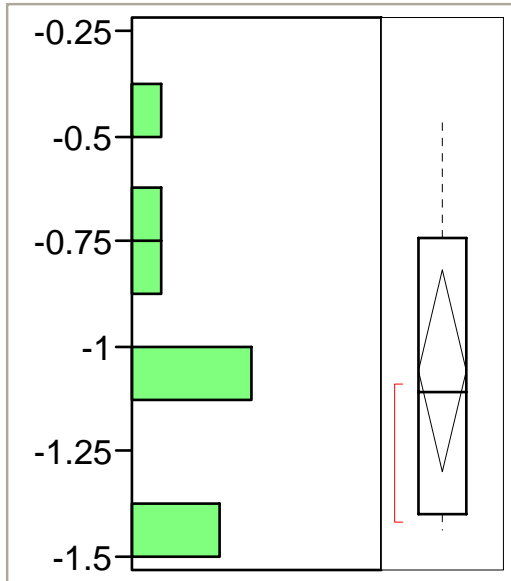
Quantiles

100.0%	maximum	-0.460
99.5%		-0.460
97.5%		-0.460
90.0%		-0.477
75.0%	quartile	-0.745
50.0%	median	-1.111
25.0%	quartile	-1.397
10.0%		-1.438
2.5%		-1.440
0.5%		-1.440
0.0%	minimum	-1.440

Moments

Mean	-1.055457
Std Dev	0.3356746
Std Err Mean	0.1061496

d13C
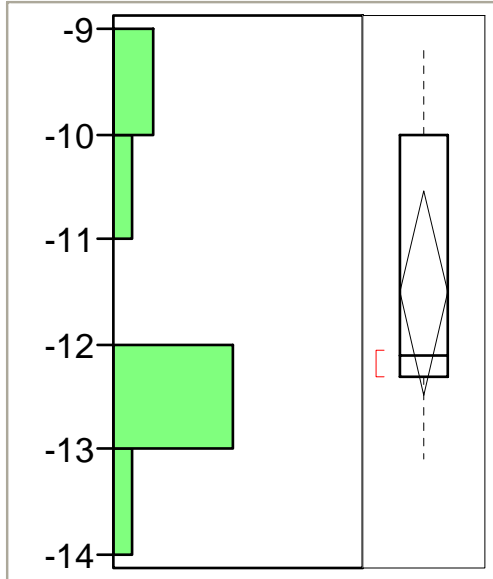
Quantiles

100.0%	maximum	-9.15
99.5%		-9.15
97.5%		-9.15
90.0%		-9.18
75.0%	quartile	-10.01
50.0%	median	-12.11
25.0%	quartile	-12.31
10.0%		-13.01
2.5%		-13.08
0.5%		-13.08
0.0%	minimum	-13.08

Moments

Mean	-11.51056
Std Dev	1.3661261
Std Err Mean	0.432007
upper 95% Mean	-10.53329
lower 95% Mean	-12.48783
N	10

Species=Human Male

Distributions

d18O
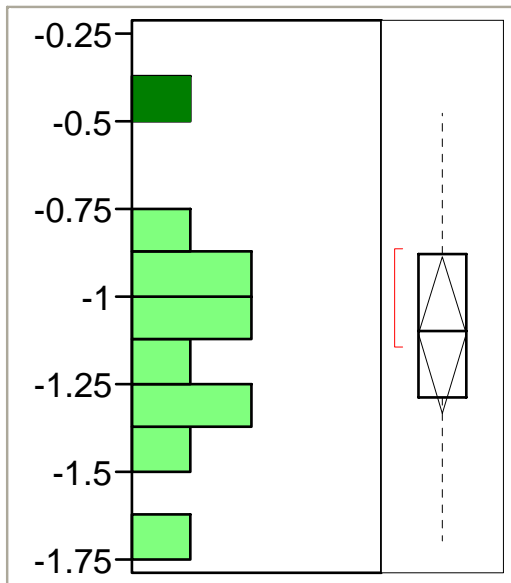
Quantiles

100.0%	maximum	-0.480
99.5%		-0.480
97.5%		-0.480
90.0%		-0.557
75.0%	quartile	-0.876
50.0%	median	-1.101
25.0%	quartile	-1.290
10.0%		-1.657
2.5%		-1.700
0.5%		-1.700
0.0%	minimum	-1.700

Moments

Mean	-1.1082
Std Dev	0.3321516
Std Err Mean	0.1001475
upper 95% Mean	-0.885057
lower 95% Mean	-1.331342
N	11

d13C
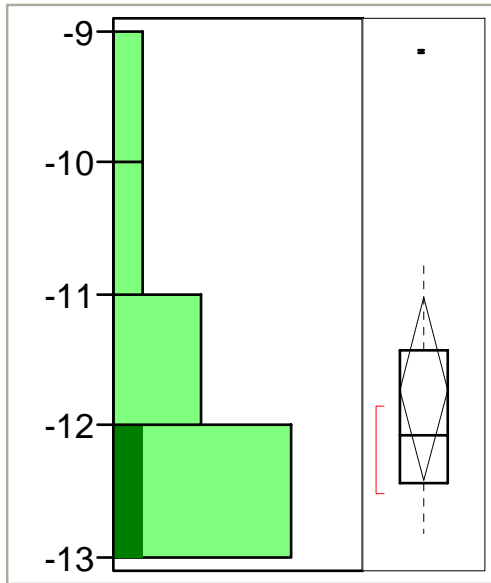
Quantiles

100.0%	maximum	-9.16
99.5%		-9.16
97.5%		-9.16
90.0%		-9.47
75.0%	quartile	-11.42
50.0%	median	-12.06
25.0%	quartile	-12.44
10.0%		-12.75
2.5%		-12.81
0.5%		-12.81
0.0%	minimum	-12.81

Moments

Mean	-11.71752
Std Dev	1.0299345
Std Err Mean	0.3105369
upper 95% Mean	-11.0256
lower 95% Mean	-12.40944
N	11
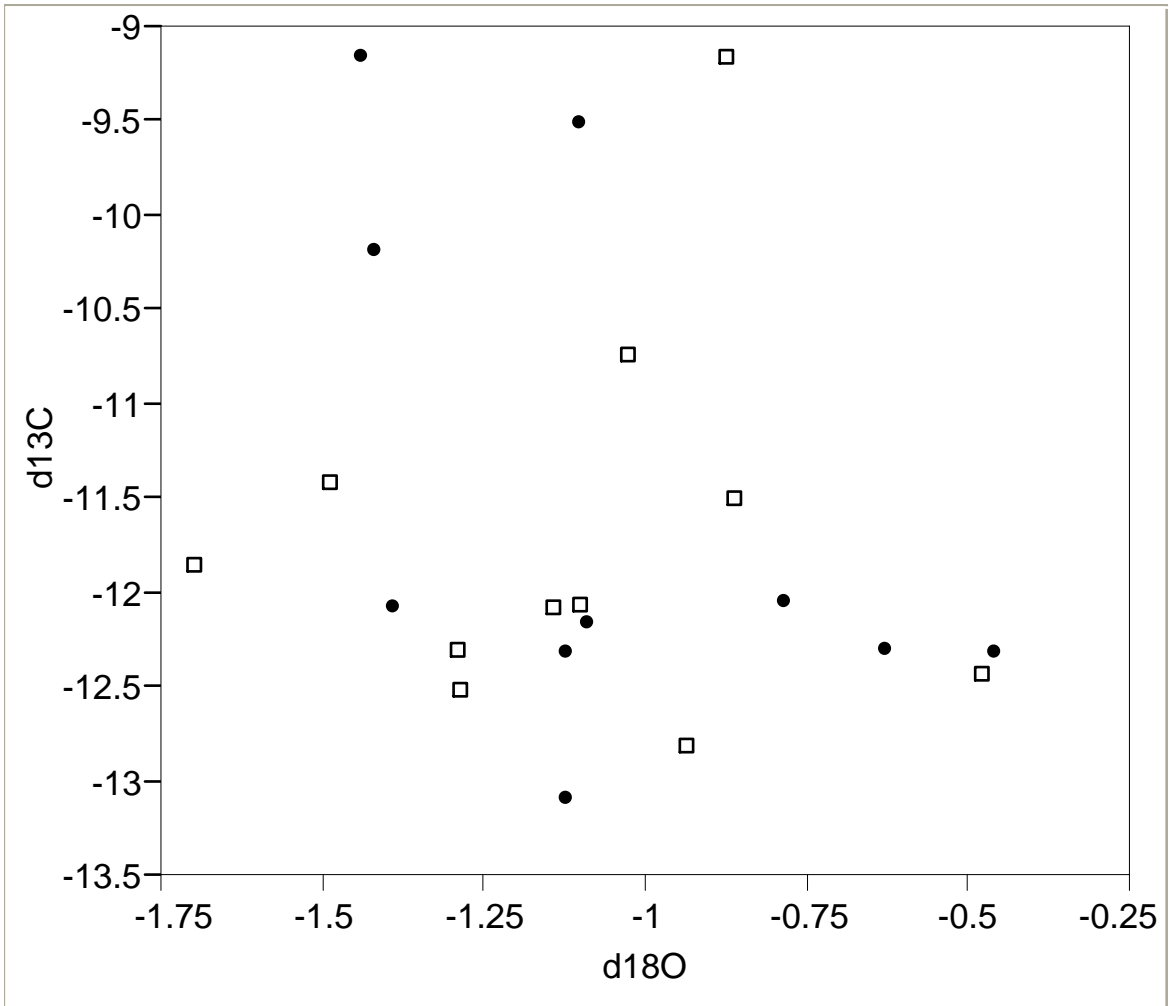
Square are males

Circles are females

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BIOGRAPHICAL SKETCH

Rachel K. Wentz was born in Hawaii, the daughter of a Navy Captain. Her family eventually settled in Orlando, Florida, where she became a Firefighter/Paramedic with the Orlando Fire Department. While a member of the department, she continued her education, completing a B.A. in Anthropology at the University of Central Florida and an M.P.A. from Troy State University. She retired from OFD after 11 years of service and came to Florida State University, completing an M.A. in Anthropology and continuing on to the doctoral degree. Her research has focused on the bioarchaeological assessment of health among the Windover (8BR246) population, with special interest in paleopathology. She intends to work as an independent contractor in the analysis of human skeletal remains.